no action

**GEORGIA INSTITUTE OF TECHNOLOGY**
**OFFICE OF CONTRACT ADMINISTRATION**
**SPONSORED PROJECT INITIATION**

Date: 9/30/77

Project Title: "Development of a Solar Radiation Model for Shenandoah."

B-536 Green card

Project No: E-15-609

Project Director: Dr. J. R. Williams

Sponsor: Sandia Laboratories

Agreement Period: From 9/22/77 Until 1/31/80 (Contract Period)

Type Agreement: Contract No. 07-6958

Amount: $99,954 (Partially funded at $43,840 through 9/30/78)

Reports Required: Monthly Technical Reports, Monthly Cost Status Reports, Final Report

Sponsor Contact Person (s):

Technical Matters

Contractual Matters (thru OCA)

George Kupper
Purchasing Organization 3721
SANDIA CORPORATION
Albuquerque, New Mexico 87115
(505) 264-1936

Defense Priority Rating: N/A

Assigned to: Office of the Dean of Engineering (School/Laboratory)

COPIES TO:

- Project Director
- Division Chief (EES)
- School/Laboratory Director
- Dean/Director—EES
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- Procurement Office
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- Library, Technical Reports Section
- Office of Computing Services
- Director, Physical Plant
- EES Information Office
- Project File (OCA)
- Project Code (GTRI)
- Other ______

**GEORGIA INSTITUTE OF TECHNOLOGY**
OFFICE OF CONTRACT ADMINISTRATION

# SPONSORED PROJECT TERMINATION

Date: 9/15/80

Project Title: DEVELOPMENT OF A SOLAR RADIATION MODEL FOR SHENANDOAH

Project No: E-15-609

Project Director: WILLIAMS/ENG.

Sponsor: SANDIA LABORATORIES

Effective Termination Date: 7/31/80

Clearance of Accounting Charges: 7/31/80

Grant/Contract Closeout Actions Remaining:

NONE; Main project account (beginning w/Mod. #3) is now E-16-660/CRAIG. This no-action closeout completes the project responsibility transfer. All future paperwork should reflect E-16-660/CRAIG/w/subproject/E-25-679/Jeter.

- _ Final Invoice and Closing Documents
- _ Final Fiscal Report
- _ Final Report of Inventions
- _ Govt. Property Inventory & Related Certificate
- _ Classified Material Certificate
- _ Other ______

Assigned to: OFFICE OF THE DEAN OF ENGINEERING (School/~~Laboratory~~)

COPIES TO:

Project Director
Division Chief (EES)
School/Laboratory Director
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Library, Technical Reports Section
EES Information Office
Project File (OCA)
Project Code (GTRI)
Other OCA RESEARCH PROPERTY COORDINATOR

CA–4 (1/79)

E-15-609

GEORGIA INSTITUTE OF TECHNOLOGY

ATLANTA, GEORGIA 30332

SCHOOL OF
MECHANICAL ENGINEERING

A-74F-S
B-407-S

March 20, 1978

Mr. G. T. Kupper
Sandia Contracting Representative
Sandia Laboratories
Albuquerque, New Mexico 87115

Subject: Contract 07-6958 - Monthly Technical Report, October 1977

Dear Mr. Kupper:

Progress on the subject contract during October 1977 is summarized in this monthly letter technical report. The report is indexed by Tasks as defined in the contract work statement and summarized for Phase 1 (October-January) in an internal memo (10-31-77) appended as Attachment I.

Task 1.1 - Contact was made with Frank Quinlan at NCC to determine the availability of Atlanta and Griffin charts. Atlanta charts are at NCC but are not accurately cataloged (Attachment II shows copies of NCC logs). A copy of a typical NCC chart is shown in Attachment III. Griffin data was from a cooperative station and was reported as daily totals only; no charts are at NCC. Dr. Futrell at the University of Georgia Agriculture Station at Griffin where the station was located was visited, but no charts could be located. He is taking pyranometer data at present on strip charts but the instrument calibration is questionable and the site is poor. In view of the poor quality and spotty records, it was decided not to consider Griffin any further.

Task 1.1 - An order was placed for a complete 480 series solar radiation tape from NCC for Atlanta since the present tape at Georgia Tech was not complete. This will be used to prepare the monthly solar radiation charts as soon as it arrives.

Task 1.3 - No progress to report.

Tasks 1.4 - 1.9 - Not begun.

Sincerely,

J. I. Craig
Associate Professor
Aerospace Engineering

JIC/cs
attachments

RECEIVED
MAR 22 1978
OFFICE OF CONTRACT ADMINISTRATION

ATTACHMENT I

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

ENGINEERING COLLEGE
OFFICE OF THE DEAN

(404) 894-3354

October 13, 1977

MEMORANDUM

TO: Jim Craig/AE
Mel Corley/ME

FROM: Richard Williams

SUBJECT: Solar Radiation Model for Shenandoah

Our contract with Sandia for the development of the Solar Radiation Model for Shenandoah was initiated October 1. According to our contract the following three tasks are to be completed this month (October):

Task 1. Determine which solar radiation charts are available and make up a table showing which charts are available each day of each year for which solar radiation data are available.

Task 2. Make up tables of Atlanta and Griffin monthly average solar radiation data, in kilowatt hours per square meter per day, for each month for which Atlanta solar radiation charts (Task 1) are available.

Task 3. From the results of Tasks 1 and 2, select the "best, most representative" year based on the monthly average solar radiation data for Atlanta and on the completeness of the instantaneous data from the solar radiation charts and to the extent possible, recover and remove all calibration, scale and recorder errors.

The following two tasks are to be completed during November and December.

Task 4. Read the solar radiation data from the available charts (using an overlay) for the selected year, filling in gaps (if any) using selected data from other years such that total daily radiation matches that for those days of the selected year.

Task 5. Convert the data obtained from Task 4 into hourly solar radiation intensity values (kilowatts per square meter) broken into direct and diffuse components, on computer tape. (The Aerospace model is to be used for this Task).

The following four tasks are to be completed in January.

Task 6. Compare the deviations, averages and normals of the selected year with the 1975 test reference year (TRY) provided by Aerospace.

Task 7. Combine the solar radiation data for Task 5 with the meterological data for the selected year. The results will be the best year of solar radiation/meterological data for the Shenandoah area based on the best available data.

(cont'd.)

Task 8. Prepare a concise report describing the model, its development, and the format for use of the data.

Task 9. Distribute a copy of the tapes and five copies of the report to Sandia and the Preliminary Design Team.

These nine tasks constitute Phase I of the program which is to be completed during a period of four months. Following Phase I, Phase II will be initiated in February, 1978 and will continue until January 31, 1980. Phase II involves utilizing data from the Shenandoah Meterological Station to update and improve the model developed under Phase I. The total funding for Phase I is $36,000 and Phase II is $63,000.

JRW/dk

ATTACHMENT II

STN. NO. 13874 STN. NAME ATLANTA, GEORGIA LAT: 33 39N LONG: 84 25W

**DAILY Form 1091**

| YR | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1949 | | | / | X | X | X | X | X | X | X | X | X |
| 50 | X | X | X | X | X | X | / | / | X | X | / | X |
| 51 | / | / | / | / | / | / | / | / | / | X | X | / |
| 52 | / | / | / | / | / | / | / | | | | | |
| 53 | | | | | | | | | | | | |
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| 55 | | | | | | | | | | | | |
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| 58 | | | | | | | | | | | | |
| 59 | | | | | | | | | | | | |
| 1960 | | | | | | | | | | | | |
| 61 | | | | | | | | | | | | |
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| 67 | | | | | | | | | | | | |
| 68 | | | | | | | | | | | | |
| 69 | | | | | | | | | | | | |

**Form 610-D**

| YR | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1949 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 51 | | | | | | | | | | | | |
| 52 | | | | | | | / | / | / | / | X | X |
| 53 | X | / | | | | | | | | | | |
| 54 | | | | | | | | | | | | |
| 55 | | | | | | | | | | | | |
| 56 | | | | | | | | | | | | |
| 57 | | | | | | | | | | | | |
| 58 | | | | | | | | | | | | |
| 59 | | | | | | | | | | | | |
| 1960 | | | | | | | | | | | | |
| 61 | | | | | | | | | | | | |
| 62 | | | | | | | | | | | | |
| 63 | | | | | | | | | | | | |
| 64 | | | | | | | | | | | | |
| 65 | | | | | | | | | | | | |
| 67 | | | | | | | | | | | | |
| 68 | X | X | / | X | X | X | X | X | / | X | / | X |
| 69 | X | X | X | X | X | X | / | | / | / | X | X |

**Circular Chart**

| YR | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | SERVICE | REMARKS ELEV: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1949 | | | | / | X | X | X | X | X | X | X | X | | |
| 50 | X | X | X | X | X | X | X | / | X | X | X | X | | |
| 51 | X | X | X | X | X | X | X | X | X | X | X | X | | |
| 52 | X | X | X | X | X | X | X | X | X | X | X | X | | |
| 53 | X | X | X | X | X | X | X | X | X | X | X | X | | |
| 54 | X | X | X | X | X | / | X | X | X | X | X | X | | |
| 55 | X | X | X | X | X | X | X | X | X | X | X | X | | |
| 56 | X | X | X | X | X | / | | | | / | X | X | | |
| 57 | X | X | X | X | X | X | X | X | X | X | X | X | | |
| 58 | X | X | X | X | X | / | / | X | X | / | / | / | | |
| 59 | X | X | X | X | X | X | X | X | X | X | X | X | | |
| 1960 | X | X | X | X | X | X | X | X | X | X | X | X | | |
| 61 | / | X | X | X | X | X | X | X | X | X | / | X | | |
| 62 | / | X | X | X | X | X | X | X | X | X | X | X | | |
| 63 | X | X | / | / | X | X | X | X | X | X | / | X | | |
| 64 | X | X | X | X | X | X | X | X | X | X | X | X | | |
| 65 | X | X | / | X | X | X | / | X | / | X | X | X | | |
| 67 | X | / | X | X | X | X | X | / | X | X | X | X | | |
| 68 | X | X | X | X | X | X | X | X | X | X | X | X | | |
| 69 | X | X | X | X | X | X | X | X | / | X | X | X | | |

CROSS - REFERENCE - INOPV: 6/30/56-10/22/56

DIEBOLD V-LINE FORM 53312(255519)

STN. NO. 13874 STN. NAME ATLANTA, GEORGIA LAT: 33 39N LONG: 84 25W

| YR. | DAILY Form B-52 | | | | | | | | | | | | Form 610-D | | | | | | | | | | | | Circular Chart | | | | | | | | | | | | SERVICE | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | ELEV: |
| 1970 | | | | | | | | | | | | | / | X | X | X | X | / | X | X | / | X | X | X | / | X | X | X | X | X | X | X | X | X | X | X | | |
| 71 | | | | | | | | | | | | | X | X | X | / | / | X | X | X | X | / | / | X | X | X | X | X | X | X | X | X | X | X | X | X | | |
| 72 | | | | | | | | | | | | | X | X | / | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | |
| 73 | | | | / | / | / | / | X | / | / | X | / | / | / | X | / | * | / | / | X | / | / | X | / | X | X | X | X | X | X | X | X | X | X | X | X | | |
| 74 | / | / | X | * | * | * | / | X | X | / | * | | / | / | X | * | * | * | / | * | X | / | * | | / | | | | | | / | X | X | | | | | |

CROSS - REFERENCE -

* No DATA

DIEBOLD V-LINE FORM 53312 (2555191

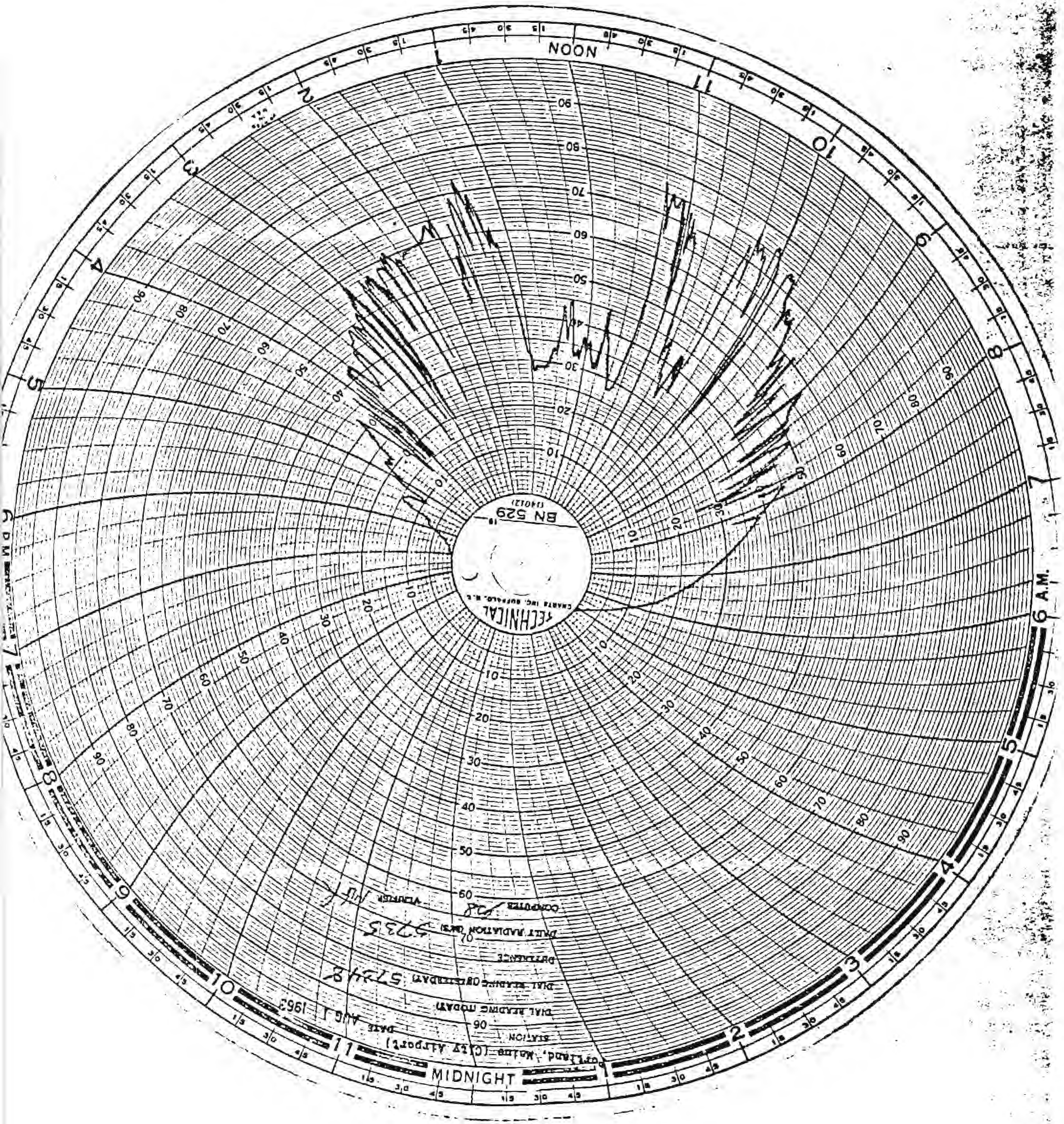
STN. NO. X3941 STN. NAME GRIFFIN EXP STN, GEORGIA LAT: 33 14N LONG: 84 25W

| | DAILY Form 610-8/1091 | | | | | | | | | | | | | | | | | | | | | | | | | Form 610-D | | | | | | | | | | | | | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YR | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | SERVICE | ELEV: |
| 1950 | | | | / | / | / | / | / | / | / | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 51 | X | X | X | X | X | X | X | X | X | X | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 52 | X | / | X | X | X | X | X | X | / | X | X | X | | | | | | | | | | | | | | | | | | | / | X | / | | | | | |
| 53 | X | / | / | X | X | / | X | / | / | X | X | / | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 54 | / | / | / | / | X | / | X | X | X | X | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 55 | X | / | / | X | X | X | X | X | X | X | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 56 | X | / | X | X | X | X | / | / | / | / | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 57 | / | X | X | X | / | / | / | / | X | X | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | 11/5/59 |
| 58 | X | X | X | X | / | / | X | X | / | | / | / | | | | | | | | | | | | | | | | | | | | | | | | | | Form 610-8 began |
| 59 | X | X | X | X | X | X | / | / | X | / | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1960 | X | / | / | X | / | / | X | X | / | / | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 61 | | / | / | X | X | X | X | / | / | X | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 62 | X | X | X | X | X | X | X | X | X | / | X | / | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 63 | X | X | / | / | X | / | X | / | X | X | X | / | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 64 | X | X | X | X | / | X | X | X | X | / | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 65 | X | X | X | X | X | X | / | X | / | / | / | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 66 | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

CROSS - REFERENCE -

DIEBOLD V-LINE FORM 53312 (255519)

ATTACHMENT III


NOON
MIDNIGHT
6 A.M.
BN 529
TECHNICAL
STATION
Portland, Maine (City Airport)
DATE Aug 1 1963
DIAL READING (TODAY)
DIAL READING (YESTERDAY)
DIFFERENCE
DAILY RADIATION (ly's)
COMPUTER
VERIFIER

Sandia Laboratories
PURCHASING ORGANIZATION

ALBUQUERQUE, NEW MEXICO 87115
LIVERMORE, CALIFORNIA 94550

# MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 31 October 1977

| | | |
|---|---|---|
| TOTAL FUNDS AUTHORIZED | | $ 43,840.00 |
| ACTUAL COST INCURRED TO DATE (2) | | 3,648.81 |
| ESTIMATED COST TO COMPLETE: (3) | | |
| 1ST MONTH FOLLOWING (1) | 3,653.33 | |
| 2ND MONTH | 3,653.33 | |
| 3RD MONTH | 3,653.33 | |
| 4TH MONTH | 3,653.33 | |
| 5TH MONTH | 3,653.33 | |
| 6TH MONTH | 3,653.33 | |
| BALANCE OF FISCAL YEAR (4) | 18,271.21 | |
| SUBSEQUENT FISCAL YEARS | 0.00 | |
| TOTAL ESTIMATE TO COMPLETE | | 40,191.19 |
| TOTAL ESTIMATED COST AT COMPLETION | | $ 43,840.00 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE.

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

SF 6432-CS (3-76)

E 15-609

GEORGIA INSTITUTE OF TECHNOLOGY

ATLANTA, GEORGIA 30332

SCHOOL OF
MECHANICAL ENGINEERING

March 20, 1978

Mr. G. T. Kupper
Sandia Contracting Representative
Sandia Laboratories
Albuquerque, New Mexico 87115

Subject: Contract 07-6958 - Monthly Technical Report, November 1977
+ Cost Status Report

Dear Mr. Kupper:

Progress on the subject contract during November 1977 is summarized in this monthly letter technical report. The report is indexed by Tasks as defined in the contract work statement and summarized for Phase 1 in the October report.

Task 1.1 - A visit was made to NCC to review the charts since the available logs proved inconclusive. Each of the charts was examined by hand and a log of available charts, their quality, and any noted problems was prepared. A copy of the log is included as Attachment I.

Task 1.2 - Using the 480 series tape from NCC, a table of monthly average solar radiation for Atlanta was prepared. The data was arranged in a matrix form as shown in Attachment II. Each year from 1952-1974 is represented by a group of 3 rows which in the first 12 columns give for each month the mean and standard deviation of the data in Langleys/day along with the fraction of days for which data are available (PERC). The 13th column contains the average of the means (the annual mean) and the average of the standard deviations (not the annual standard deviation) and the annual fraction of data available. The last row in the matrix, year 99, contains entries for each month (column) that are determined in the same manner as the 13th column but are for a particular month rather than a year.

Task 1.3 - It is possible with reference to the matrix to select the most representative months using as selection criteria:

1. The monthly mean matches the long term average.
2. The monthly standard deviation matches the long term average of the standard deviation.
3. The month contains a minimum of missing days.

Consideration was given to developing an optimization routine, but eventually, it was decided that the selection could be clearly made by hand. The objective in using the above criteria is to match as closely as possible the first two moments of the distribution function for the solar data. No consideration is given to other meteorological data (e.g., ambient temperature) and, therefore, the resultant values of these data may not agree either with long term averages or with other models

(TRY, etc.). Using the criteria, the following months have been selected:

| | |
|---|---|
| January 1953 | July 1970 |
| February 1971 | August 1959 |
| March 1969 | September 1963 |
| April 1965 | October 1967 |
| May 1957 | November 1967 |
| June 1957 | December 1970 |

Task 1.4 - Plans were worked out with NCC personnel to carry out the digitization of the selected charts. The charts (Attachment III shows typical one) contain a non-linear scale that greatly compounds automated reading. After much deliberation, a novel and efficient method was developed that would allow digitization to be made at 15 minute intervals. Since the charts are ruled in 15 minute increments, it is relatively simple to read off the radial coordinate for each time line where the trace crosses. This yields a sequential record of radiation at 15 minute intervals relative to the starting hour. The process was automated somewhat by use of NCC's HP9830 calculator and digitizer which allowed the actual coordinates to be read and stored on cassette tapes. Since the data are taken sequentially, one only needs to know the starting hour and the insolation can be computed from the radial distance of the point from the origin which is the chart center. No more than a single day was missing from any month, and these were filled with equivalent data from other years.

Task 1.5 - No progress to report.

Sincerely,

J. I. Craig
Associate Professor
Aerospace Engineering

JIC/cs
attachments

ATTACHMENT I

Station: Atlanta
Year: 1973

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| January | 12 | Bad | |
| | 14 | Bad | |
| | 15 | | Time adjustment |
| February | 28 | Missing 0800-1000 | |
| March | | No Faults | |
| April | 23 | No afternoon data | |
| | 24 | No afternoon data | New Epply serial #7544 constant 1.77, 1308 |
| | 26 | | Used old pyranometer only |
| May | 23-31 | Missing | |
| June | 1-7 | Missing | |
| | 8 | Missing morning through 1430 | |
| | 13 | | Out of service 0900-1100, 1100 to 1430 |
| | 18 | | Out of service 0800-1130 |
| | 19 | | Out of service 1500-1800 |
| | 29 | Missing | |
| | 30 | Missing | |
| July | 1 | Missing | |
| | 2 | Missing | |
| | 3 | Missing morning through 1415 | |
| August | | No Faults | |
| September | | No Faults | |
| October | 18 | Missing 1100 through 1200 | |
| November | | | Honeywell Charts |
| December | 2 | Missing 1330 through 1445 | |
| | 4 | Out of range from 1000 to 1100 | |
| | 6 | | Data erratic - note on chart says clear all day |
| | 9 | | No data from 1130 to 1200 |
| | 30 | | No data until 1600 |
| | 31 | | Data too high |

Station: Atlanta
Year: 1957

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| January | 16 | No data from 0830-1330 | |
| | 22 | No data from 1030-1300 | |
| | 27 | | Very erratic |
| | 28 | | Note says counter erratic |
| | 29-31 | | Counter erratic, however solar data looks good |
| February | 4 | No data until 1300 | |
| | 19 | No data until 1145-on | |
| March | | No Faults | |
| April | | No Faults | |
| May | | No Faults | |
| June | | No Faults | |
| July | 2 | | No data after 1700 due to ink smear |
| | 3 | Legible data only between 1515-1900 | |
| | 29 | | Eligible from 1615-1730 due to ink smear |
| August | | No Faults | |
| September | 10 | | Pen stuck from 1010-1145 |
| October | 16 | No data after 1315 | |
| | 17 | No data | |
| | 24 | No data after 0845 | |
| November | | No Faults | |
| December | 8 | | Data eligible from 1015-1045 due to ink smear |

Station: Atlanta
Year: 1956

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| January | | No Faults | |
| February | 25 | | No reading from 0910-1540 |
| | 27 | No data after 1000 | |
| | 28 | No data | Recorder inoperative |
| | 29 | No data | Recorder inoperative |
| March | 20 | | Data bearly legible from 1100-1200 |
| April | | No Faults | |
| May | 15 | | Ink pen skipping from 1140-1500 |
| June | 6 | No data | |
| | 7 | No data till 0845 | |
| | 11-30 | No data | |
| July | | No data | |
| August | | No data | |
| September | | No data | |
| October | | No data until 22, at 1420 | |
| November | 3-5 | No data | |
| December | 10 | No data | |

Station: Atlanta
Year: 1955

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| January | | No Fault | |
| February | 15 | | Out of service from 0815-rest of day |
| | 16 | | Not in service until 1400 |
| | 18 | | Eligible from 1100 on |
| | 19 | Missing | |
| | 20 | Missing | |
| | 21 | | Eligible |
| | 22 | Missing | |
| | 23 | Missing | |
| | 24-28 | Missing | |
| March | | No data until March 15 | |
| April | | No Faults | |
| May | | No Faults | |
| June | | No Faults | |
| July | | No Faults | |
| August | 26 | | Clock out of calibration all day, solar readings seem to be in tact |
| | 27 | | Clock reset, readings from 0900-on |
| September | 4 | | Power failure on readings from 1315-on |
| October | 10 | | Solar data bearly legible till 1000, no data after 1000 |
| | 11-12 | | Bearly legible |
| | 18 | | No data from 1100-on |
| November | | No Faults | |
| December | 1 | | No data from 1430 on - recorder failed |

Station: Atlanta
Year: 1954

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| January | 13 | Bad data from 1200-1300 | |
| | 19 | Bad data from 1100-1200 | |
| | 25 | Bad data from 0845-0915 | |
| | 23 | | Pen stuck from 1115-1500 |
| | 23 | | Pen stuck from 1215-1400 |
| | 30 | Bad data from 1430-1600 | |
| February | 6 | Bad data from 1245-1520 | |
| | 15 | Bad data from 1440-1510 | |
| | 17 | Bad data from 1440-1510 | |
| | 18 | Bad data from 1410 | |
| | 19 | | Pen stuck from 1430-1500 |
| | 21 | | Pen stuck from 1015-1115, 1310-1445, 1700-1815 |
| | 22 | | Pen stuck from 1230-1310 and 1700-1830 |
| | 23 | | Pen stuck from 1520-1615 |
| | 25 | Bad data from 1350-1430 and 1030-1200 | |
| March | | No faults | |
| April | 4 | | Pen sticking from 1245-1340 |
| | 10 | | Pen sticking from 1145-1300, and 1340-1500 |
| | 11 | | Pen sticking from 0915-1010, and 1650-1820 |
| | 12 | | Pen stuck from 1100-1450 |
| | 14 | | Pen stuck from 1045-1130 |
| | 20 | | Pen stuck from 1315-1520 |
| | 21 | | Pen stuck from 1130-1205 |
| | 22 | | Pen stuck from 1020-1210 and 1220-1230 |
| | 24 | | Pen stuck from 1100-1200 |
| | 26 | No data from 0820-1530 | |
| May | | No Faults | |
| June | 30 | Missing | |
| | 29 | Bad data from 0845 on | |

Station: Atlanta
Year: 1954 (Continued)

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| July | 6 | | Out of service for calibration until 1330 |
| | 8 | | Out of service until 1130 |
| | 9 | | No good data for whole day, chart slipped |
| August | | No Faults | |
| September | 14 | | Ran out of ink at 1315 |
| | 28 | | Chart eligible from 1100-1500 |
| | 29 | | Pen was running out of ink or clogged very hard to read between 0900-1100 |
| October | | No Faults | |
| November | | No Faults | |
| December | | No Faults | |

Station: Atlanta
Year: 1953

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| January | 5 | | Clock was 43 minutes fast at 0900 so it was set back to 0815 |
| February | 8 | No data until-1000 | |
| | 27 | | Pen stuck from 1640-1800 |
| March | 19 | | Battery changed from 0910-0920 |
| | 14 | | Pen stuck from 1245-1515 |
| | 15 | | Pen stuck from 1030-1240, 1315-1345 |
| | 18 | | Pen stuck from 1130-1330 |
| April | 1 | | Pen stuck from 1230-1320, and 1040-1110 |
| | 3 | No data from 0815-1110 | |
| | 2 | | Pen sticking from 1100-1315 |
| | 22 | No data from 0920-1430 | |
| May | 24 | No data from 0915-1315 | |
| June | 6 | | Pen sticking for 15 minute intervals between 0900-1000, 1000-1100 |
| | 8 | | Pen sticking for 5 to 10 minutes, 5 times |
| | 9 | | Pen stuck from 1200-1430 |
| July | 15 | Bad data from1420-1520 | |
| August | 5 | Data missing from 1300-1400 | |
| | 2 | Bad data from 0730-0915 | |
| | 10 | Bad data from 1045-1300 | |
| | 9 | Bad data from 1100-1420 | |
| | 21 | No data from 1515-1600 | |
| September | 2 | No data from 1040-1140 | |
| | 12 | | Pen stuck from 0730-0830 |

Station: Atlanta
Year: 1953 (Continued)

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| October | 20 | Bad data from 1140-1240 | |
| | 16 | BAd data from 1245-1430 | |
| November | 7 | No data from 1015-1045 | |
| | 18 | Bad data from 1030-1045 | |
| December | 8 | | Pen stuck from 1015-1045 and 1320-1350 |
| | 6 | | Pen stuck from 1330-1615 |
| | 4 | | Pen stuck from 1330-1730 |
| | 15 | Data missing from 0800-0845 | |
| | 12 | Data missing from 1445-1530 | |

Station: Atlanta
Year: 1952

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| January | | No Faults | |
| February | 21 | | Pen stuck between 1015-1235 |
| | 25 | | Service by technican from 1030-1130 |
| | 29 | Bad data from 1130-1215 | |
| March | 5 | | Pen stuck from 1020-1120 |
| | 7 | | Pen stuck from 1030-1230 |
| | 11 | | Pen stuck from 0815-0830, 0900-0920, 0940-1020, 1040-1120 |
| | 21 | | Being serviced by technican 0945-1600 |
| April | 6 | | Pen sticking from 1030-1100, 1120-1200, 1210-1230, 1240-1400 |
| | 9 | No data from 1210-1240 | |
| | 18 | | Pen stuck from 1315-1345 and 1420-1445 |
| | 19 | | Pen stuck from 1400-1430 |
| | 20 | Bad data from 1445 on | |
| May | 4 | | Pen stuck from 1145-1330 |
| | 23 | | Pen sticking most of the day |
| June | 4 | | Pen sticking from 1345-1430 |
| | 8 | | Power failure from 0945-1030, Pen stuck from 1430-1530 |
| | 15 | | Pen stuck from 1240-1420 |
| | 17 | | Pen stuck from 1530-1620 |
| | 28 | | Pen stuck from 1330-1400 |
| July | 3 | | Pen out of ink from 1500-1545 |
| | 4 | | Pen out of ink from 0915-1130 |
| | 14 | | Pen stuck from 1330-1445 |
| | 16 | | Pen stuck from 1245-1345 |
| | 20 | Bad data from 1545 on | |
| | 21 | Bad data from 1400 on | |
| | 22 | | Pen sticking from 1415-1500 |
| | 26 | | Pen stuck from 1700-1800 |
| | 27 | | Pen sticking in various parts of the day for no more than 10 minutes at a time |
| | 28 | | Pen sticking from 1630-1700 |

Station: Atlanta
Year: 1952 (Continued)

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| August | 3 | | Pen sticking from 1345-1420, and 1430-1510, 1115-1215, 1430-1500, 1515-1540 |
| | 12 | | Pen stuck from 1340-1420 |
| | 14 | | Pen stuck from 1440-1530 |
| | 15 | | Pen stuck from 1530-1640 |
| | 18 | | Pen stuck from 1230-1520, and 1640-1730 |
| | 19 | | Pen sticking from 1000-1220 |
| | 20 | | Pen sticking from 1345-1815 |
| | 26 | | Pen stuck from 1330-1400 |
| | 28 | | Pen sticking from 1415-1500 |
| September | 2 | No data from 1020 on | |
| | 3 | No data until 0815 | |
| | 5 | No data from 0840-1115 | |
| October | 18 | Bad data from 0820-0830 | |
| | 20 | | Off for maintenance from 1245-1300 |
| November | | No Faults | |
| December | | No Faults | |

Station: Atlanta
Year: 1951

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| January | 17 | Bad data 1320-1400 also 1430-1515 | |
| | 18 | Bad data 1415-1450 | |
| | 19 | Bad data 1015-1030 also 1040-1050, 1220-1300, 1450-1610 | |
| | 22 | No data | Machine was off for recalibration |
| | 24 | | 1345 timer reset to 1400 |
| | 25 | | Timer reset at 0840; reset to 0920 |
| | 29 | Bad data from 0830-0900 | |
| February | 19 | | Pen arm stuck from 1200 till 0400 |
| March | 5 | | Pen arm stuck between 1400-1800 |
| | 7 | | Pen stuck between 1130-1500 |
| April | 1 | Bad data from 1115-1320 | |
| | 12 | | Clock stopped at 0945 and was out the rest of the day |
| | 3 | | Pen ran out of ink from 1000-1330 |
| | 19 | | Pen stopped from 1330-1445 Pen stuck again from 1700-1845 |
| | 21 | Bad data from 1300-1320 | |
| | 22 | Bad data from 1130-1200 | |
| | 24 | Bad data from 1250-1340 | |
| | 27 | Bad data from 1030-1130 | |
| | 28-29 | | Recording instrument having problems, giving bad data for both days |
| | 30 | | Recording machine off from 1430-1440 |
| May | 4 | Bad data from 1215-1245 | |
| | 11 | Bad data from 1030-1130 | |
| | 15 | | Maintenance, dry cell changed |
| | 23 | | Off for maintenance from 1130-1200 |

Station: Atlanta
Year: 1951 (Continued)

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| June | | | Unusually deep trough in the radiation data as if something was completely blocking it from 1100-1300 |
| | 10 | | Data was not taken until 0900 as pen was not on arm |
| | 26 | | No data from 1000-night |
| July | 1 | Bad data from 1130-1345 | |
| | 3 | | Pen out of ink from 0900-1145 |
| | 8 | | No data from 1145-1500 |
| | 14 | | No data from 1115-1530 |
| | 20 | | No data from 1145-1445 |
| | 29 | | No data from 0900-1430 |
| | 30 | | Pen stuck between 1015-115 |
| August | | No Faults | |
| September | 11 | | Pen stuck between 1110-1240 |
| | 12 | | Pen stuck from 1015-1120 |
| | 21 | Bad data from 0745-0900 | |
| | 24 | | Pen stuck between 1045-1130 |
| October | 31 | | Battery changed between 0815-0845 |
| November | 15 | | Time corrected between 1115-1145 |
| December | 1 | | Time changed between 1400-1415 |
| | 8 | Bad data from 0945-1215 | |
| | 28 | Bad data from 1240-1415 | |

ATTACHMENT II

ATLANTA, GA

Daily Totals (Ly)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | YEAR 52 | | | | | | | | | | |
| MEAN | 0 | 0 | 0 | 0 | 0 | 0 | 555 | 420 | 461 | 389 | 265 | 218 | 352 |
| STDDEV | 0 | 0 | 0 | 0 | 0 | 0 | 124 | 146 | 135 | 128 | 119 | 104 | 123 |
| PERC | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | .29 | .55 | .90 | .87 | 1.00 | 1.00 | .77 |
| | | | YEAR 53 | | | | | | | | | | |
| MEAN | 215 | 294 | 403 | 553 | 562 | 582 | 543 | 588 | 462 | 410 | 279 | 213 | 419 |
| STDDEV | 114 | 137 | 209 | 207 | 198 | 171 | 139 | 103 | 176 | 101 | 96 | 118 | 147 |
| PERC | 1.00 | .90 | .84 | .83 | .84 | .80 | .97 | .68 | .90 | .84 | .83 | .81 | .85 |
| | | | YEAR 54 | | | | | | | | | | |
| MEAN | 240 | 327 | 456 | 513 | 592 | 676 | 583 | 540 | 470 | 386 | 256 | 210 | 441 |
| STDDEV | 108 | 134 | 155 | 203 | 211 | 132 | 82 | 91 | 111 | 89 | 128 | 97 | 126 |
| PERC | .74 | .55 | 1.00 | .60 | 1.00 | .93 | .87 | 1.00 | 1.00 | 1.00 | 1.00 | .97 | .89 |
| | | | YEAR 55 | | | | | | | | | | |
| MEAN | 216 | 276 | 373 | 507 | 534 | 583 | 496 | 528 | 361 | 354 | 285 | 193 | 391 |
| STDDEV | 126 | 140 | 182 | 175 | 162 | 133 | 113 | 92 | 136 | 101 | 106 | 96 | 130 |
| PERC | 1.00 | .90 | .97 | 1.00 | .97 | 1.00 | 1.00 | .81 | .97 | .90 | 1.00 | .97 | .96 |
| | | | YEAR 56 | | | | | | | | | | |
| MEAN | 240 | 247 | 416 | 518 | 543 | 575 | 0 | 0 | 0 | 290 | 305 | 237 | 367 |
| STDDEV | 100 | 164 | 163 | 185 | 159 | 110 | 0 | 0 | 0 | 101 | 114 | 112 | 139 |
| PERC | 1.00 | .86 | 1.00 | 1.00 | 1.00 | .33 | 0.00 | 0.00 | 0.00 | .23 | .97 | 1.00 | .82 |
| | | | YEAR 57 | | | | | | | | | | |
| MEAN | 226 | 294 | 365 | 521 | 527 | 524 | 602 | 568 | 332 | 328 | 231 | 218 | 400 |
| STDDEV | 115 | 144 | 214 | 173 | 175 | 153 | 134 | 99 | 179 | 136 | 120 | 102 | 145 |
| PERC | .84 | .83 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | .80 | .90 | 1.00 | 1.00 | .95 |
| | | | YEAR 58 | | | | | | | | | | |
| MEAN | 240 | 365 | 344 | 427 | 537 | 547 | 527 | 509 | 446 | 355 | 264 | 229 | 394 |
| STDDEV | 103 | 147 | 168 | 186 | 154 | 148 | 94 | 98 | 153 | 131 | 108 | 106 | 134 |
| PERC | 1.00 | .97 | 1.00 | 1.00 | 1.00 | .73 | .55 | 1.00 | 1.00 | 1.00 | .77 | .90 | .91 |
| | | | YEAR 59 | | | | | | | | | | |
| MEAN | 219 | 236 | 392 | 455 | 498 | 552 | 484 | 472 | 378 | 262 | 269 | 192 | 373 |
| STDDEV | 117 | 152 | 185 | 199 | 145 | 114 | 116 | 90 | 128 | 147 | 105 | 91 | 132 |
| PERC | .55 | .97 | 1.00 | 1.00 | 1.00 | .97 | 1.00 | 1.00 | .93 | .94 | .97 | 1.00 | .94 |
| | | | YEAR 60 | | | | | | | | | | |
| MEAN | 200 | 304 | 344 | 430 | 503 | 487 | 461 | 449 | 366 | 323 | 271 | 217 | 362 |
| STDDEV | 126 | 185 | 175 | 166 | 124 | 95 | 106 | 108 | 138 | 103 | 106 | 92 | 125 |
| PERC | .97 | 1.00 | .58 | 1.00 | 1.00 | 1.00 | .94 | .84 | .97 | 1.00 | .93 | .97 | .93 |
| | | | YEAR 61 | | | | | | | | | | |
| MEAN | 280 | 239 | 334 | 492 | 490 | 480 | 553 | 438 | 445 | 398 | 242 | 165 | 388 |
| STDDEV | 63 | 158 | 158 | 176 | 206 | 179 | 108 | 150 | 88 | 82 | 96 | 111 | 135 |
| PERC | .48 | .97 | .94 | 1.00 | 1.00 | 1.00 | 1.00 | .97 | 1.00 | .94 | .73 | .97 | .92 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR 62 | | | | | | | | | | | | | |
| MEAN | 184 | 305 | 387 | 489 | 625 | 583 | 585 | 546 | 441 | 412 | 253 | 217 | 413 |
| STDDEV | 111 | 145 | 177 | 163 | 66 | 142 | 129 | 85 | 152 | 108 | 128 | 103 | 123 |
| PERC | 1.00 | .86 | .90 | .33 | .87 | 1.00 | .97 | 1.00 | 1.00 | .97 | 1.00 | 1.00 | .91 |
| YEAR 63 | | | | | | | | | | | | | |
| MEAN | 218 | 342 | 442 | 506 | 568 | 511 | 575 | 485 | 390 | 429 | 265 | 232 | 413 |
| STDDEV | 119 | 147 | 202 | 201 | 168 | 223 | 144 | 127 | 132 | 84 | 114 | 106 | 146 |
| PERC | .97 | .93 | 1.00 | .83 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | .98 |
| YEAR 64 | | | | | | | | | | | | | |
| MEAN | 217 | 286 | 397 | 425 | 556 | 592 | 474 | 485 | 425 | 356 | 274 | 176 | 390 |
| STDDEV | 123 | 147 | 203 | 225 | 170 | 122 | 169 | 144 | 151 | 142 | 98 | 90 | 149 |
| PERC | 1.00 | 1.00 | 1.00 | .97 | 1.00 | .97 | 1.00 | 1.00 | .97 | 1.00 | .97 | .84 | .98 |
| YEAR 65 | | | | | | | | | | | | | |
| MEAN | 252 | 284 | 312 | 483 | 616 | 472 | 509 | 502 | 382 | 365 | 240 | 235 | 389 |
| STDDEV | 103 | 154 | 182 | 169 | 101 | 176 | 116 | 93 | 152 | 124 | 108 | 98 | 129 |
| PERC | .94 | .93 | .77 | 1.00 | 1.00 | .83 | .97 | 1.00 | .90 | 1.00 | .97 | 1.00 | .94 |
| YEAR 66 | | | | | | | | | | | | | |
| MEAN | 193 | 246 | 451 | 458 | 481 | 580 | 476 | 451 | 393 | 312 | 235 | 202 | 373 |
| STDDEV | 124 | 161 | 158 | 152 | 223 | 126 | 169 | 130 | 143 | 154 | 101 | 97 | 144 |
| PERC | 1.00 | .93 | 1.00 | 1.00 | 1.00 | 1.00 | .97 | .97 | 1.00 | .97 | 1.00 | 1.00 | .99 |
| YEAR 67 | | | | | | | | | | | | | |
| MEAN | 212 | 272 | 405 | 495 | 497 | 477 | 485 | 427 | 409 | 345 | 258 | 167 | 370 |
| STDDEV | 105 | 156 | 139 | 164 | 213 | 170 | 133 | 157 | 137 | 128 | 124 | 95 | 143 |
| PERC | .97 | .97 | .94 | 1.00 | 1.00 | 1.00 | 1.00 | .94 | .97 | 1.00 | 1.00 | 1.00 | .98 |
| MEAN | 183 | 307 | 446 | 418 | 520 | 567 | 492 | 495 | 384 | 298 | 222 | 197 | 376 |
| STDDEV | 118 | 127 | 115 | 200 | 159 | 135 | 137 | 130 | 114 | 126 | 109 | 96 | 130 |
| PERC | 1.00 | .97 | .74 | 1.00 | 1.00 | 1.00 | .97 | 1.00 | .97 | 1.00 | .97 | 1.00 | .97 |

YEAR 69

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MEAN | 167 | 245 | 387 | 446 | 473 | 489 | 0 | 0 | 376 | 327 | 275 | 193 | 332 |
| STDDEV | 100 | 146 | 162 | 186 | 182 | 116 | 0 | 0 | 128 | 108 | 82 | 109 | 132 |
| PERC | 1.00 | .97 | 1.00 | 1.00 | 1.00 | .87 | 0.00 | 0.00 | .30 | .87 | 1.00 | 1.00 | .90 |

YEAR 70

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MEAN | 236 | 324 | 347 | 441 | 538 | 501 | 517 | 439 | 429 | 275 | 240 | 192 | 379 |
| STDDEV | 115 | 125 | 170 | 184 | 191 | 149 | 128 | 123 | 87 | 134 | 130 | 101 | 137 |
| PERC | .39 | .97 | 1.00 | 1.00 | 1.00 | .90 | 1.00 | 1.00 | .97 | 1.00 | 1.00 | 1.00 | .93 |

YEAR 71

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MEAN | 192 | 284 | 385 | 526 | 582 | 556 | 443 | 444 | 372 | 282 | 275 | 158 | 374 |
| STDDEV | 114 | 146 | 201 | 163 | 172 | 110 | 133 | 109 | 128 | 143 | 87 | 82 | 132 |
| PERC | 1.00 | .97 | 1.00 | .93 | .97 | 1.00 | 1.00 | 1.00 | .97 | .97 | .93 | 1.00 | .98 |

YEAR 72

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MEAN | 174 | 216 | 370 | 483 | 437 | 496 | 455 | 413 | 334 | 252 | 168 | 124 | 326 |
| STDDEV | 108 | 132 | 154 | 124 | 134 | 158 | 94 | 73 | 79 | 94 | 96 | 82 | 110 |
| PERC | 1.00 | 1.00 | .97 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

YEAR 73

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MEAN | 156 | 228 | 235 | 392 | 0 | 515 | 455 | 415 | 333 | 287 | 204 | 168 | 292 |
| STDDEV | 88 | 105 | 145 | 162 | 0 | 130 | 92 | 91 | 108 | 116 | 85 | 86 | 107 |
| PERC | .94 | .93 | 1.00 | .87 | 0.00 | .30 | .90 | 1.00 | .97 | .94 | 1.00 | .90 | .89 |

YEAR 74

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MEAN | 0 | 0 | 0 | 0 | 0 | 0 | 499 | 385 | 327 | 446 | 0 | 0 | 371 |
| STDDEV | 0 | 0 | 0 | 0 | 0 | 0 | 143 | 111 | 146 | 41 | 0 | 0 | 125 |
| PERC | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | .19 | 1.00 | 1.00 | .10 | 0.00 | 0.00 | .57 |

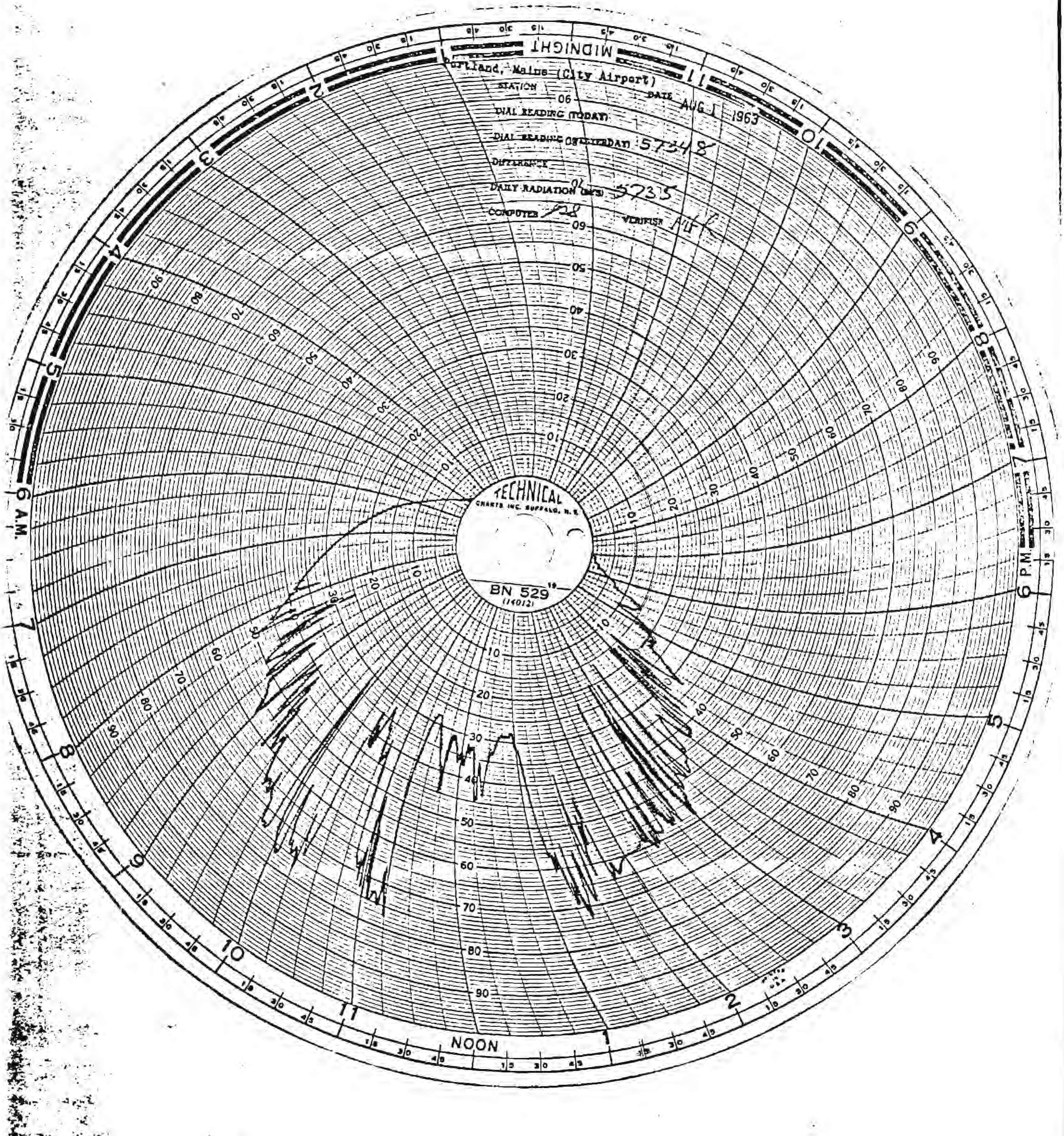
YEAR 99

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MEAN | 208 | 280 | 380 | 473 | 532 | 539 | 511 | 475 | 396 | 339 | 252 | 197 | 377 |
| STDDEV | 110 | 144 | 172 | 178 | 165 | 143 | 123 | 111 | 130 | 117 | 107 | 98 | 131 |
| PERC | .89 | .92 | .94 | .92 | .98 | .89 | .88 | .94 | .93 | .89 | .96 | .97 | .91 |

13.114 CP SECONDS EXECUTION TIME

/

ATTACHMENT III


MIDNIGHT
Portland, Maine (City Airport)
STATION
DATE AUG 1 1963
DIAL READING (TODAY)
DIAL READING (YESTERDAY)
DIFFERENCE
DAILY RADIATION
COMPUTER
VERIFIER
TECHNICAL
CHARTS INC. BUFFALO, N.Y.
BN 529
6 A.M.
NOON
6 P.M.

Sandia Laboratories
PURCHASING ORGANIZATION

ALBUQUERQUE, NEW MEXICO 87115
LIVERMORE, CALIFORNIA 94550

MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 30 November 1977

| | | |
|---|---|---|
| TOTAL FUNDS AUTHORIZED | | $ 43,840.00 |
| ACTUAL COST INCURRED TO DATE (2) | | 7,564.88 |
| ESTIMATED COST TO COMPLETE: (3) | | |
| 1ST MONTH FOLLOWING (1) | 3,653.33 | |
| 2ND MONTH | 3,653.33 | |
| 3RD MONTH | 3,653.33 | |
| 4TH MONTH | 3,653.33 | |
| 5TH MONTH | 3,653.33 | |
| 6TH MONTH | 3,653.33 | |
| BALANCE OF FISCAL YEAR (4) | 14,355.14 | |
| SUBSEQUENT FISCAL YEARS | 0.00 | |
| TOTAL ESTIMATE TO COMPLETE | | 36,275.12 |
| TOTAL ESTIMATED COST AT COMPLETION | | $ 43,840.00 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE.

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
MECHANICAL ENGINEERING

March 20, 1978

Mr. G. T. Kupper
Sandia Contracting Representative
Sandia Laboratories
Albuquerque, New Mexico 87115

Subject: Contract 07-6958 - Monthly Technical Report, December 1977.

Dear Mr. Kupper:

Progress on the subject contract during December 1977 is summarized in this monthly letter technical report. The report is indexed by Tasks as defined in the contract work statement and summarized for Phase 1 in the October report.

Task 1.4 - A visit was made to NCC and in two days the selected charts were digitized and stored on cassette tapes. Xerox copies of all digitized charts were also obtained for reference. After some exploration, a 9830 calculator with suitable peripherals to allow copying the cassettes to Georgia Tech's CDC mainframe was located in Albany, Georgia. A rental arrangement was worked out and the machine was used to read the cassettes and transmit the data over the phone to the campus computer. Next, an extensive period of data verification was carried out. Copies of each chart were constructed on a graphics terminal, using digitized data, and the result was compared to the Xerox chart copy. Any shifts or discrepancies were removed by editing. Then each chart record was scaled and numerically integrated, and the resultant daily total was compared to the tabulated NCC value (from the ball-and-disc integrator in the site recorder). If a discrepancy of 2% or more was found, the chart data was reexamined and adjusted if possible. (A bad integrator reading was found in one case!) Finally, the data were corrected for any problems noted on the charts and the results stored in CDC files.

Task 1.5 - As per R. W. Hunke's letter of 20 December 1977 to Charles Randall at Aerospace Corporation, this task effort will be carried out by the latter upon receipt of a tape copy of the measured model year global radiation. In its place, Georgia Tech has instead calculated the direct and diffuse components on the basis of the Liu and Jordan decomposition procedure.

Sincerely,

J. I. Craig
Associate Professor
Aerospace Engineering

JIC/cs

Sandia Laboratories
PURCHASING ORGANIZATION

ALBUQUERQUE, NEW MEXICO 87115
LIVERMORE, CALIFORNIA 94550

# MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 31 December 1977

| | | |
|---|---|---|
| TOTAL FUNDS AUTHORIZED | | $ 43,840.00 |
| ACTUAL COST INCURRED TO DATE (2) | | 10,570.53 |
| ESTIMATED COST TO COMPLETE: (3) | | |
| 1ST MONTH FOLLOWING (1) | 3,653.33 | |
| 2ND MONTH | 3,653.33 | |
| 3RD MONTH | 3,653.33 | |
| 4TH MONTH | 3,653.33 | |
| 5TH MONTH | 3,653.33 | |
| 6TH MONTH | 3,653.33 | |
| BALANCE OF FISCAL YEAR (4) | 11,349.49 | |
| SUBSEQUENT FISCAL YEARS | 0.00 | |
| TOTAL ESTIMATE TO COMPLETE | | 33,269.47 |
| TOTAL ESTIMATED COST AT COMPLETION | | $ 43,840.00 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE.

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

GEORGIA INSTITUTE OF TECHNOLOGY

ATLANTA, GEORGIA 30332

SCHOOL OF
MECHANICAL ENGINEERING

March 20, 1978

Mr. G. T. Kupper
Sandia Contracting Representative
Sandia Laboratories
Albuquerque, New Mexico 87115

Subject: Contract 07-6958 - Monthly Technical Report, January 1978

Dear Mr. Kupper:

Progress on the subject contract during January 1978 is summarized in this monthly letter technical report. The report is indexed by Tasks as defined in the contract work statement and summarized for Phase 1 in the October report.

Task 1.6 - The comparison was made by Aerospace Corporation and Sandia since the reference tapes were not available to Georgia Tech. Due to the selection criteria used for the TRY, which favor matching non-solar meteorological variables for a real year, it is not felt that a close match will result or should be expected.

Task 1.7 - The surface observations from the TDF-14 series tapes were processed and combined with the corresponding solar model year months to form a SOLMET-type tape file. Due to major transcription problems, only a limited number of the SOLMET fields were filled (e.g., the cloud type, amount, height fields were not copied). In addition, some problem has been encountered with respect to the uniformity of data since in 1965 the Weather Service changed from hourly to 3-hourly observations. Also, data for two early months were available only in 6-hour intervals. The resultant file now contains both solar and surface observations for the model year. An attempt was made to obtain rehabilitation information from NOAA so that the present raw observations can be corrected for instrument drift and error. However, after lengthy discussion with Frank Quinlan (NCC) and Jerry Cotten (NOAA/ERL), it was found that this information would likely not be available in time. Accordingly, it was decided to distribute the raw observations at this time and work on corrections later.

Task 1.8 - In progress with nothing to report at this time.

Task 1.9 - Copies of the SOLMET tape were distributed to Sandia, Aerospace Corporation, and General Electric on 3 February 1978. Attachment I provides a copy of the reference document.

Sincerely

J. I. Craig
Associate Professor
Aerospace Engineering

JIC/cs
attachment

ATTACHMENT I

# MAGNETIC TAPE FORMAT

# SHENANDOAH SOLAR MODEL YEAR

## 1.0 General

The Shenandoah Solar Model Year (SSMY) tapes being prepared at Georgia Tech contain either reconstructed solar data from NWS observations at Atlanta or actual measured data from the Shenandoah Met Station or a combination of both. The data are distributed in the SOLMET format and include only those observations made at the site met station or NWS observations directly related to them. All other tape fields are blanked with 9's as required in the format. Several different releases will be made as more data becomes available and those will be identified by different numbers in the Tape Deck field (001). Normally, this field would contain 9724 for the NWS/NCC SOLMET tapes. For the SSMY, this field will contain sequential numbers starting with 0001 which will indicate successive releases of data.

## 2.0 Tape Characteristics

The SSMY-SOLMET tapes are being distributed in a form that is identical to the NWS-SOLMET tapes. The characteristics are as follows:

Tape: 9 track, EBCDIC, odd parity, 1600 bpi

Label: none

Logical Record: 163 bytes (characters) long

Blocking: 24 logical records (3912 bytes) per physical tape record

The tape contains no overpunches or alpha characters and missing data are encoded as 9's.

## 3.0 Tape Fields

The SOLMET tape fields used for the SSMY tapes are shown below. Data shown as 9's are not supplied. Data shown as X's are supplied in SOLMET units.

| Tape Field | Data |
|---|---|
| 001 | XXXX |
| 002 | 13874 |
| 003 | XXXXXXXXXX |
| 004 | XXXX |
| 101 | XXXX |
| 102 | 7XXXX |
| 103 | 7XXXX |
| 104 | 99999 |
| 105 | 99999 |
| 106 | 0XXXX |
| 107 | 0XXXX |
| 108 | 99999 |
| 109 | 99999 |
| 110 | 99999 |
| 111 | 99 |
| 201 | XX |
| 202 | XXXX |
| 203 | 9999 |
| 204 | 9999 |
| 205 | 99999999 |
| 206 | XXXXXXXXXX |
| 207 | XXX0XXX0 |
| 208 | XXXXXXX |
| 209-210 | all 9's |

Sandia Laboratories
PURCHASING ORGANIZATION

ALBUQUERQUE, NEW MEXICO 87115
LIVERMORE, CALIFORNIA 94550

# MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 31 January 1978

| | | |
|---|---|---|
| TOTAL FUNDS AUTHORIZED | | $ 43,840.00 |
| ACTUAL COST INCURRED TO DATE (2) | | 14,631.93 |
| ESTIMATED COST TO COMPLETE: (3) | | |
| 1ST MONTH FOLLOWING (1) | 3,653.33 | |
| 2ND MONTH | 3,653.33 | |
| 3RD MONTH | 3,653.33 | |
| 4TH MONTH | 3,653.33 | |
| 5TH MONTH | 3,653.33 | |
| 6TH MONTH | 3,653.33 | |
| BALANCE OF FISCAL YEAR (4) | 7,288.09 | |
| SUBSEQUENT FISCAL YEARS | 0.00 | |
| TOTAL ESTIMATE TO COMPLETE | | 29,208.07 |
| TOTAL ESTIMATED COST AT COMPLETION | | $ 43,840.00 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE.

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

GEORGIA INSTITUTE OF TECHNOLOGY

ATLANTA, GEORGIA 30332

SCHOOL OF
MECHANICAL ENGINEERING

March 20, 1978

Mr. G. T. Kupper
Sandia Contracting Representative
Sandia Laboratories
Albuquerque, New Mexico 87115

Subject: Contract 07-6958 - Monthly Technical Report, February 1978

Dear Mr. Kupper:

Progress on the subject contract during February 1978 is summarized in this monthly letter technical report. The report is indexed by Tasks as defined in the contract work statement and summarized for Phase 1 in the October report.

Task 1.7 - A correction procedure was developed to rehabilitate the solar data. It is patterned after a method outlined by Bahm (Proceedings of the 1977 Annual Meeting, American Section of the International Solar Energy Society, Orlando, Florida, June 1977). Basically, the NCC 480 series tape of daily total solar observations was scanned, and for each 20 day interval in sequence, the clearest day (i.e., highest global total radiation) was selected. These "clear day" values were then plotted sequentially over the station lifetime to yield a station history. Using instrument replacement data from Ed Flowers (NOAA/ARL) shown in Attachment I, the periods of operation of each instrument were identified. Next, within the period of operation of each instrument, a linear regression analysis was made to determine the degree of long-term drift. It was thus assumed that the instrument would start with a known calibration value and drift or age at an approximately constant rate that could be detected by systematic changes in its clear day operation. Using this procedure, the following correction factors were developed for each month:

| | | | |
|---|---|---|---|
| January | 1.0000 | July | 1.0216 |
| February | 1.0515 | August | 1.0836 |
| March | 1.0000 | September | 1.0000 |
| April | 1.0034 | October | 1.0634 |
| May | 1.0156 | November | 1.0656 |
| June | 1.0183 | December | 1.0474 |

These values are the interpolation of the regression line for that particular month during the year. As can be seen, the maximum error is about 8%. These corrections along with some alterations in the tape format are now under way and will be provided as Release 2 of the SOLMET tape during March 1978.

Task 1.8 - Under way.

Sincerely,

J. I. Craig
Associate Professor
Aerospace Engineering

JIC/cs
attachment

ATTACHMENT I

| | PROBLEM | FLAT CORR. FACTOR | DATE | PROBLEM | LINEAR CORR. FACTOR |
|---|---|---|---|---|---|
| | | **ASTORIA, OR** | | | |
| | | Sensor # 1798 (L) | | | |
| 1-30-53 - 1-28-54 | On Smithsonian Scale | .98 | 1-20-53 to 1-28-54 | Recalibration | 1.0 to 1.028* |
| | | | | *7-2-40 - 1-1-53 at North Head, WA | |
| 1-28-54 - 7-1-57 | | Sensor #1719 (L) | | | |
| 1-28-54 - 7-1-57 | On Smithsonian Scale | .98 | 1-28-54 - 3-5-62 | Recalibration | 1.0 to .961 |
| 7-1-57 - 1-30-59 | None | | | | |
| 1-30-59 - 1-20-61 | On Smithsonian Scale | .98 | | | |
| 1-20-61 - 3-5-62 | None | | | | |
| | | Sensor #606 (P) | | | |
| 3-5-62 - 1-6-65 | Insufficient Data | | 3-5-62 - 1-6-65 | Broken | |
| | | Sensor # 2621 (P) | | | |
| 1-6-65 - 5-12-66 | | <1% | 1-6-65 - 5-10-67 | Recalibration | 1.0 to 1.013 |
| 5-12-66 - 11-16-66 | Midscale Chart Setting | 1.017 | | | |
| 11-16-66 - 5-10-67 | | <1% | | | |
| | | Sensor #2063 (P) | | | |
| 5-10-67 - 6-11-70 | | <1% | 5-19-67 - Present | None | |
| 6-11-70 - 6-3-71 | Midscale Chart Setting | .983 | | | |
| 6-3-71 - 11-30-71 | (Same) | .987 | | | |
| 11-30-71 - 4-24-73 | (Same) | .983 | | | |
| 4-24-73 - Present | None | | | | |
| | | **ATLANTA, GA** | | | |
| | | Sensor #1832 (L) | | | |
| 3-5-49 - 4-7-53 | Smithsonian Scale | .98 | 3-5-49 - 7-8-54 | Recalibration | 1.0 to .934 |
| | Midscale Chart Setting | 1.014 | | | |

| DATE | PROBLEM | FLAT CORR. FACTOR | DATE | PROBLEM | LINEAR CORR. FACTOR |
|---|---|---|---|---|---|
| | | ATLANTA, GA (Cont'd) | | | |
| | | Sensor #1832 (L) (Cont'd) | | | |
| 4-7-53 - 4-30-54 | Smithsonian Scale | .98 | | | |
| | Midscale Chart Setting | 1.019 | | | |
| 4-30-54 - 7-8-54 | Smithsonian Scale | .98 | | | |
| | | Sensor #1608 (L) | | | |
| 7-8-54 - 6-19-56 | Smithsonian Scale | .98 | 7-8-54 - 6-19-56 | Broken | |
| 6-19-56 - 10-22-56 | No data | | | | |
| | | Sensor #1796 (L) | | | |
| 10-22-56 - 10-16-57 | Smithsonian Scale | .98 | 10-22-56 - 3-6-60 | Broken | |
| 10-16-57 - 3-6-60 | None | | | | |
| | | Sensor #2271 (P) | | | |
| 3-19-60 - 11-21-61 | None Available | | 3-19-60 - 11-21-61 | Broken | |
| | | Sensor #655 (P) | | | |
| 11-28-61 - 2-8-65 | None Available | | 11-28-61 - 2-8-65 | Broken | |
| | | Sensor #2599 (P) | | | |
| 2-8-65 - 11-29-68 | Crossmatch | .930 | 2-8-65 - 11-29-68 | Recalibration | 1.0 to 1.072 |
| | | Sensor #3327 (P) | | | |
| 11-28-68 - 9-24-69 | None | | 11-29-68 - 9-24-69 | Broken | |
| | | Sensor #1803 (P) | | | |
| 9-24-69 - 1-30-70 | None | | 9-24-69 - 1-30-70 | Broken | |

| DATE | PROBLEM | FLAT CORR. FACTOR | DATE | PROBLEM | LINEAR CORR. FACTOR |
|---|---|---|---|---|---|
| | | ATLANTA, GA (Cont'd) | | | |
| | | Sensor #1610 (P) | | | |
| 1-30-70 - 4-24-73 | None | | 1-30-70 - 4-24-73 | Recalibration | 1.0 to 1.255 |
| | | Sensor #7544 (P) | | | |
| 1-24-73 - 6-28-73 | None | | 4-24-73 - 6-28-73 | None | |
| | | Sensor #10565F4 | | | |
| -28-73 - 7-3-73 | None | | 6-8-73 - 7-3-73 | Broken | |
| | | Sensor #11938F3 | | | |
| -3-73 - 7-25-74 | None | | 7-3-73 - 7-25-74 | Broken | |
| | | Sensor #9903F3 | | | |
| -25-74 - 11-5-74 | None | | 7-25-74 - 11-5-74 | Broken (Closed) | |
| | | AUBURN, AL | | | |
| | | Sensor #5665 (P) | | | |
| -15-68 - 12-4-68 | None | | 2-15-68 - 12-4-68 | None | |
| | | Sensor #5268 (P) | | | |
| 2-4-68 - 11-20-74 | Wrong Cal. Constant | 1.039 | 12-4-68 - 11-20-4 | None Available | |
| 2-4-68 - 1-18-72 | | <1% | | | |
| -18-72 - 3-12-73 | Midscale Chart Setting | 1.019 | | | |
| -12-73 - 11-20-74 | | <1% | | | |

NO FURTHER INFORMATION

Sandia Laboratories
PURCHASING ORGANIZATION

ALBUQUERQUE, NEW MEXICO 87115
LIVERMORE, CALIFORNIA 94550

# MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 28 February 1978

| | | |
|---|---|---|
| TOTAL FUNDS AUTHORIZED | | $ 43,840.00 |
| ACTUAL COST INCURRED TO DATE(2) | | 18,481.97 |
| ESTIMATED COST TO COMPLETE:(3) | | |
| 1ST MONTH FOLLOWING (1) | 3,653.33 | |
| 2ND MONTH | 3,653.33 | |
| 3RD MONTH | 3,653.33 | |
| 4TH MONTH | 3,653.33 | |
| 5TH MONTH | 3,653.33 | |
| 6TH MONTH | 3,653.33 | |
| BALANCE OF FISCAL YEAR(4) | 3,438.05 | |
| SUBSEQUENT FISCAL YEARS | | |
| TOTAL ESTIMATE TO COMPLETE | | 25,358.03 |
| TOTAL ESTIMATED COST AT COMPLETION | | $ 43,840.00 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE.

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

E15-609

GEORGIA INSTITUTE OF TECHNOLOGY

ATLANTA, GEORGIA 30332

SCHOOL OF
MECHANICAL ENGINEERING

April 19, 1978

Mr. G. T. Kupper
Sandia Contracting Representative
Sandia Laboratories
Albuquerque, New Mexico 87115

Subject: Contract 07-6958 - Monthly Technical Report, March 1978

Dear Mr. Kupper:

Progress on the subject contract during March 1978 is summarized in this monthly letter technical report. The report is indexed by Tasks as defined in the contract work statement and summarized for Phase 1 in the October report. Since the contract is now entering Phase 2, a copy of the work statement including this phase is included for reference as Attachment I.

Task 1.8 - The Phase 1 report is undergoing final revision and will be forwarded either before or along with the April monthly technical progress report.

Task 1.9 - Correction procedures to rehabilitate the solar model year engineering observations have been applied. The approach taken was outlined under Task 1.7 in the February report. The rehabilitated data were forwarded as Release 2 to Dr. C. M. Randall at Aerospace Corporation on 22 March 1978 so that he could perform the decomposition of total insolation on the horizontal into beam and diffuse components. Specific changes made in Release 2 are as follows:

- Multiple day entries have been corrected.
- Engineering observations of total insolation have been corrected for instrument calibration and drift.
- Solar-local time conversion now includes the equation of time in addition to the longitude correction.
- The meteorological surface observations have been taken from a single TDF-14 tape rather than from several sources as was done for Release 1.
- Tape blocks are now exactly 3912 characters long (not 3920 as for Release 1). This problem is the result of special CDC file handling procedures which by default restrict blocks to multiples of 10 characters and has not affected the data.

Task 2.1 - Data from the Met Station is presently available from September through mid-December 1977. Processing of more recent data is currently underway at EG&G and Georgia Tech.

Task 2.2 & 2.3 - The present solar model year is being compared with all available insolation data bases for Atlanta. Present plans are to compare with (1) the Aerospace Insolation Data Base, (2) a Georgia Tech Atlanta model year synthesized from cloud cover observations, (3) The ASHRAE/Liu and Jordan long term monthly average daily total insolation data, and (4) the most appropriate NOAA/ERL model predictions. A more detailed outline of this work will be provided in later monthly reports.

Sincerely,

J. I. Craig
Associate Professor
Aerospace Engineering

JIC/cs
enclosures

Sandia Laboratories
PURCHASING ORGANIZATION

ALBUQUERQUE, NEW MEXICO 87115
LIVERMORE, CALIFORNIA 94550

# MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 3-31-78

| | | |
|---|---|---|
| TOTAL FUNDS AUTHORIZED | | $ 43,840.00 |
| ACTUAL COST INCURRED TO DATE (2) | | 21,764.91 |
| ESTIMATED COST TO COMPLETE: (3) | | |
| 1ST MONTH FOLLOWING (1) | 3,653.33 | |
| 2ND MONTH | 3,653.33 | |
| 3RD MONTH | 3,653.33 | |
| 4TH MONTH | 3,653.33 | |
| 5TH MONTH | 3,653.33 | |
| 6TH MONTH | 3,808.44 | |
| BALANCE OF FISCAL YEAR (4) | | |
| SUBSEQUENT FISCAL YEARS | | |
| TOTAL ESTIMATE TO COMPLETE | | 22,075.09 |
| TOTAL ESTIMATED COST AT COMPLETION | | $ 43,840.00 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE.

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

# WORK STATEMENT

## Development of a Solar Radiation Model for Shenandoah

The proposed program is aimed at developing a new solar radiation/meteorological model for Shenandoah to be used in connection with the Solar Total Energy Large Scale Experiment. This program is divided into 2 phases, Phase 1 being the development of a model using the solar radiation data from the Atlanta airport, and Phase 2 using actual solar and weather data from the meteorological station established by Sandia in Shenandoah. These Phases are sub-divided into several Tasks as follows and are to be accomplished in accordance with the attached schedule.

Phase 1 (4 months) - Develop Model for Conceptual Design

Task 1.1 Determine which solar radiation charts are available and make up a table showing which charts are available each day of each year for which solar radiation data are available.

Task 1.2 Make up tables of Atlanta and Griffin monthly average solar radiation data, in $KWh/m^2d$, for each month for which Atlanta solar radiation charts (Task 1.1) are available.

Task 1.3 From the results of Tasks 1.1 and 1.2, select the "best, most representative" year based on the monthly average solar radiation data for Atlanta and on the completeness of the instantaneous data from the solar radiation charts. To the extent possible, recover and remove all calibration scale and recorder errors.

Task 1.4 Read the solar radiation data from the available charts using an overlay for the selected year, filling in gaps (if any) using selected data from other years such that the total daily radiation matches that for those days of the selected year.

Task 1.5 Convert the data obtained from Task 1.4 into hourly solar radiation intensity values ($KW/m^2$), broken into direct and diffuse components, on computer tape, using the aerospace model.

Task 1.6 Compare the deviations, averages and normals of the selected year with the 1975 test reference year (TRY) provided by Aerospace.

Task 1.7 Combine the solar radiation data for Task 1.5 with the meteorological data for the selected year. The result will be the best year of solar radiation/meteorological data for the Shenandoah area based on the best available data.

Task 1.8 Prepare a concise report describing the model, its development, and the format and use of the data.

Task 1.9 Distribute a copy of the tapes and 5 copies of the report to Sandia and the Preliminary Design Team.

Phase 2 (2 years) -- Development of an Improved Solar Radiation Model Using Shenandoah Meteorological Station Data

Task 2.1 Utilizing data from the Shenandoah Meteorological Station (SMS), record these data in the SOLMET format. This Task is already funded by ERDA and no additional funding is authorized for this Task.

Task 2.2 Evaluate the recorded data, using the SMS log book for reference, in order to discard or upgrade erroneous measurements.

Task 2.3 Develop the "most reasonable" data set to fill in gaps in the SMS data, based on hourly data from previous years, recorded data for other meteorological stations during the period of the gap, and recent instantaneous data for the SMS.

Task 2.4 After 6 months of data have been collected, prepare a complete 6 month model in SOLMET format on tape for distribution to Sandia and the STE-LSE Designer. Prepare a report describing the data, its preparation, and its use. Distribute 1 copy of the tape and 5 copies of the report to Sandia and the designer. This tape will be designated SMS Model for (time period).

Task 2.5 Compare the solar radiation normals, extremes, means and deviations of the SMS Model with the model from Task 1.7. Information from 2.5 is to be included in the Task 2.4 report.

Task 2.6 Repeat Tasks 2.4 and 2.5 after one year of SMS data are obtained. The model will now contain a full year of data.

Task 2.7 Repeat Tasks 2.4 and 2.5 after two years of SMS data are obtained. The model will now contain two full years of data.

Task 2.8 Compare the means and extremes of the two years of data (Task 2.7) with available long term means and extremes.

Task 2.9 Prepare and submit 10 copies of a final report.

~~E25-679~~
E15-609

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
AEROSPACE ENGINEERING

404-894-3000

DANIEL GUGGENHEIM SCHOOL
OF AERONAUTICS

May 8, 1978

Mr. G. T. Kupper
Sandia Contracting Representative
Sandia Laboratories
Albuquerque, N.M. 87115

Subject: Contract 07-6958, Monthly Technical Report, April 1978

Dear Mr. Kupper:

Progress on the subject contract during April 1978 is summarized in this monthly letter technical report. The report is indexed by Tasks as defined in the Attachment to the March 1978 report.

Task 2.1 - Met Station Solar data from 1 September 1978 through 20 December 1978 are being examined and compared to the Solar Model Year (SMY) data. Due to the amount of missing data and some questions about the quality, it has not been possible as yet to include this data directly in the SMY. Work is now underway to resolve questions with this data.

Tasks 2.2, 2.3-continuing

Task 1.8 - The Phase I report is complete and preliminary copies will be delivered to R. Hunke. A copy is included with this letter report. Upon final approval from Sandia, copies of the report will be prepared and distributed to Sandia and to all members of the GE design team.

A meeting will be held shortly with R. Hunke to resolve problems in acquiring data from the site met station. Since this has major implications for Phase II, a revised Phase II work statement will be prepared and forwarded with the May report.

Sincerely,

J. I. Craig
Associate Professor
Aerospace Engineering

RECEIVED
MAY 19 1978
OFFICE OF CONTRACT ADMINISTRATION

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PURL ORGANIZATION

ALBUQUERQUE, NEW MEXICO
LIVERMORE, CALIFORNIA 94550

# MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 4-30-78

| | |
|---|---|
| TOTAL FUNDS AUTHORIZED | $ 43,840.00 |
| ACTUAL COST INCURRED TO DATE (2) | 25,519.79 |
| ESTIMATED COST TO COMPLETE: (3) | |
| 1ST MONTH FOLLOWING (1) | 3,653.33 |
| 2ND MONTH | 3,653.33 |
| 3RD MONTH | 3,653.33 |
| 4TH MONTH | 3,653.33 |
| 5TH MONTH | 3,706.89 |
| 6TH MONTH | |
| BALANCE OF FISCAL YEAR (4) | |
| SUBSEQUENT FISCAL YEARS | |
| TOTAL ESTIMATE TO COMPLETE | 18,320.21 |
| TOTAL ESTIMATED COST AT COMPLETION | $ 43,840.00 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE.

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

SF 6432-CS (3-76)

# DEVELOPMENT OF A SOLAR MODEL YEAR FROM NATIONAL WEATHER SERVICE CHART DATA

MARCH 1978

Prepared by

Georgia Institute of Technology
School of Aerospace Engineering
School of Mechanical Engineering
Atlanta, Georgia 30332

Sandia Contract No. 07-6958

TABLE OF CONTENTS

ABSTRACT

The development of a solar model year directly from National Weather Service chart data archived at the National Climatic Center is described. A procedure for constructing a pseudo year model by selecting from all available months those 12 which most nearly match the long term measured characteristics in a weak statistical sense. The months were selected to most nearly match the monthly means and standard deviations of the daily total global insolation. No attempt was made to match any other meteorological characteristics. The chart data of daily global insolation for each month were digitized at 15 minute intervals and were corrected for long term instrument drift. The correction was based on a linear regression analysis of the daily total insolation measurement for the clearest of each group of 40 days over the lifetime of the particular instrument. Finally, the model year data were assembled into a SOLMET format which included selected surface observations from the TDF-14 series data as well as a decomposition of the global insolation into beam and diffuse components.

## 1.0 Introduction

One of the first tasks to be faced in designing an advanced solar energy system is that of defining and obtaining a suitable solar radiation data base for the proposed site. While some type of solar radiation measurements have been made during the past several decades at over 100 sites across the U.S., much of the data is of questionable quality and beset with frequent gaps. Observations of high quality and accuracy have been made only at a very few sites, however, this meager data will be considerably expanded after 1977 as measurements from some 28 new or improved National Weather Service (NWS) solar observation stations become available. In addition, this network will be supplemented by more extensive solar and meterological data from 8 regional solar meteorological research and training sites. In the interim, however, one must rely upon data from a patchwork of sources or else must synthesize suitable data from correlations on the other observations.

The planned Solar Total Energy Large Scale Experiment at Shenandoah, Georgia, which will provide medium temperature steam for electric power generation, absorption cooling and process heat for a knit-wear plant, is typical of advanced solar energy systems currently under design. In order to fully explore the range of possible solar collector subsystems, storage subsystems, and operating strategies to meet a given load, the designers must have available some representative and suitably detailed solar radiation data base. Unfortunately, the only available data in this case consisted of the daily totals of global insolation recorded by the NWS at the Atlanta Airport station some 35 miles to the northeast and the similar daily totals recorded by the NWS cooperative station at Griffin, Georgia, roughly 40 miles to the south. While over 20 years of data were available, only the daily totals were recorded and no hourly data so essential for properly evaluating transient system performance were logged.

The present study was therefore initiated in an attempt to provide, from the best available sources, an insolation data base consiting of hourly values of the total horizontal or global insolation along with the beam and diffuse components and selected meterological data (e.g., dry-bulb temperature, wind conditions). As a starting point, these data were to be assembled in a format covering one year of 8760 hourly records which are referred to in the remainder of this report as the Solar Model Year (SMY). In subsequent work, this SMY will be expanded and updated by incorporating actual observations obtained from a solar meteorological station that has been in operation at the Shenandoah, Georgia, proposed site since September 1, 1977.

A number of different methods have been proposed for use in constructing solar data bases from other meteorolgical data when no primary measurements of solar radiation exist. These procedures are generally based on correlations established between cloud cover and other variables and actual measured solar radiation at a limited number of sites. These will not be discussed here and due to the generally poor correlation and lack of hourly meteorological data in recent years (3 hour intervals have been used since the mid sixties) were not considered for use in constructing the present SMY. Rather, the present effort was directed towards development of procedures for employing the large amounts of daily total global insolation data collected by the NWS and archived at the National Climatic Center (NCC) at Asheville, N.C. This data is available in a few cases as hourly observations but generally as daily totals that were originally obtainedfrom mechanical integrators incorporated into the chart recorders used to log the pyranometer outputs. The integrator daily totals were the primary observations, however, the original charts from NWS stations were archived as well since they contained operational notes, integrator start and end of day readings, and generally provided our indication of the instrument system operational status. Generally, only the daily totals are available from cooperative stations and no chart or other primary data records were available.

The major portion of the present work was devoted to two points, (i) development of a decision procedure for selecting the most suitable data from among all available data, and (ii) design of an efficient procedure for extracting hourly data in a computer readable format from the daily charts. Ultimately, these methods were applied to produce a SMY for Atlanta that could be used as a solar radiation data base for the aforementioned system design. The report describes in some detail the methods used, the amount of effort required to execute them, and the results obtained. A detailed comparison of the present SMY with other available data will be presented in a later report.

## 2.0 Available Solar Data

At the outset of the study, contact was made with the NCC in order to ascertain precisely what data from the Atlanta region had been archived. Daily totals of the global insolation measured over approximately 20 years at the Atlanta Airport NWS station and at the University of Georgia Agricultural Experiment Station at Griffin, Georgia have been archived. Unfortunately, the Griffin station (which is no longer archived) was a cooperative station and consequently no original chart data have been retained at the NCC. Personnel at the Griffin Agricultural Experiment Station were contacted in an effort to determine whether or not the original chart recordings had been retained at the station. Apparently at some point during operation of the station this data was either misplaced or destroyed, and at present the only available chart data consists of approximately the past 3 years of pyranometer data recorded continuously on strip charts. However, in view of the relatively poor quality (uncertain instrument calibration and poor sensor site) and spotty records, it was decided not to consider the Griffin data any further.

A visit was made to the NCC to determine the quality and the extent of the charts archived for Atlanta. Table 1 shows copies of the NCC logs of the chart data received from Atlanta and the daily totals received from Griffin. As might be expected, when the actual charts were examined it was found that a small percentage of the charts were either misfiled or misplaced. More importantly, however, it was found that much useful station operation data (instrument changes, recalibrations, malfunctions) was available on the charts. A sample copy of a typical chart is shown in Figure 1. A simple procedure was developed to examine each chart by hand in monthly groups and to record the significant notations or missing charts on a small portable cassette tape recorder. The entire set of charts covering over 20 years were examined in this manner in little over 1 man-day. Subsequently,

TABLE 1
NATIONAL CLIMATIC CENTER LOG OF ATLANTA CHARTS

STN. NO. 13874 STN. NAME ATLANTA, GEORGIA LAT: 33 39N LONG: 84 25W

SERVICE | REMARKS | ELEV:

DAILY Form 1091

| YR | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1949 | | | / | X | X | X | X | X | X | X | X | X |
| 50 | X | X | X | X | X | X | / | / | X | X | / | X |
| 51 | / | / | / | / | / | / | / | / | / | X | X | / |
| 52 | / | / | / | / | / | / | / | | | | | |
| 53 | | | | | | | | | | | | |
| 54 | | | | | | | | | | | | |
| 55 | | | | | | | | | | | | |
| 56 | | | | | | | | | | | | |
| 57 | | | | | | | | | | | | |
| 58 | | | | | | | | | | | | |
| 59 | | | | | | | | | | | | |
| 1960 | | | | | | | | | | | | |
| 61 | | | | | | | | | | | | |
| 62 | | | | | | | | | | | | |
| 63 | | | | | | | | | | | | |
| 64 | | | | | | | | | | | | |
| 65 | | | | | | | | | | | | |
| 67 | | | | | | | | | | | | |
| 68 | | | | | | | | | | | | |
| 69 | | | | | | | | | | | | |

Form 610-D

| YR | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1949 | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | |
| 51 | | | | | | | | | | | | |
| 52 | | | | | | | / | / | / | / | X | X |
| 53 | X | / | | | | | | | | | | |
| 54 | | | | | | | | | | | | |
| 55 | | | | | | | | | | | | |
| 56 | | | | | | | | | | | | |
| 57 | | | | | | | | | | | | |
| 58 | | | | | | | | | | | | |
| 59 | | | | | | | | | | | | |
| 1960 | | | | | | | | | | | | |
| 61 | | | | | | | | | | | | |
| 62 | | | | | | | | | | | | |
| 63 | | | | | | | | | | | | |
| 64 | | | | | | | | | | | | |
| 65 | | | | | | | | | | | | |
| 67 | | | | | | | | | | | | |
| 68 | X | X | / | X | X | X | X | X | / | X | / | X |
| 69 | X | X | X | X | X | X | / | | / | / | X | X |

Circular Chart

| YR | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1949 | | | | / | X | X | X | X | X | X | X | X |
| 50 | X | X | X | X | X | X | X | / | X | X | X | X |
| 51 | X | X | X | X | X | X | X | X | X | X | X | X |
| 52 | X | X | X | X | X | X | X | X | X | X | X | X |
| 53 | X | X | X | X | X | X | X | X | X | X | X | X |
| 54 | X | X | X | X | X | / | X | X | X | X | X | X |
| 55 | X | X | X | X | X | X | X | X | X | X | X | X |
| 56 | X | X | X | X | X | / | | | | / | X | X |
| 57 | X | X | X | X | X | X | X | X | X | X | X | X |
| 58 | X | X | X | X | X | / | / | X | X | / | / | / |
| 59 | X | X | X | X | X | X | X | X | X | X | X | X |
| 1960 | X | X | X | X | X | X | X | X | X | X | X | X |
| 61 | / | X | X | X | X | X | X | X | X | X | / | X |
| 62 | / | X | X | X | X | X | X | X | X | X | X | X |
| 63 | X | X | / | / | X | X | X | X | X | X | / | X |
| 64 | X | X | X | X | X | X | X | X | X | X | X | X |
| 65 | X | X | / | X | X | X | / | X | / | X | X | X |
| 67 | X | / | X | X | X | X | X | / | X | X | X | X |
| 68 | X | X | X | X | X | X | X | X | X | X | X | X |
| 69 | X | X | X | X | X | X | X | X | / | X | X | X |

CROSS - REFERENCE -
INOPV: 6/30/56-10/22/56

STN. NO. 13874 STN. NAME ATLANTA, GEORGIA LAT: 33 39N LONG: 84 25W

SERVICE | REMARKS | ELEV:

DAILY Form B-52

| YR. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | | | | | | | | | | | | |
| 71 | | | | | | | | | | | | |
| 72 | | | | | | | | | | | | |
| 73 | | | | / | / | / | / | X | / | / | X | / |
| 74 | / | / | X | + | + | + | / | X | X | / | + | |

Form 610-D

| YR. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | / | X | X | X | X | / | X | X | / | X | X | X |
| 71 | X | X | X | / | / | X | X | X | X | / | / | X |
| 72 | X | X | / | X | X | X | X | X | X | X | X | X |
| 73 | / | / | X | / | + | / | / | X | / | / | X | / |
| 74 | / | / | X | + | + | + | / | + | X | / | + | |

Circular Chart

| YR. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | / | X | X | X | X | X | X | X | X | X | X | X |
| 71 | X | X | X | X | X | X | X | X | X | X | X | X |
| 72 | X | X | X | X | X | X | X | X | X | X | X | X |
| 73 | X | X | X | X | X | X | X | X | X | X | X | X |
| 74 | / | | | | | | / | X | X | | | |

CROSS - REFERENCE -
+ No DATA

TABLE 1 cont'd

NATIONAL CLIMATIC CENTER LOG OF GRIFFIN DATA

STN NO. X3941 STN. NAME GRIFFIN EXP STN, GEORGIA LAT: 33 14N LONG: 84 25W

| YR | DAILY Form 610-8/1091 | | | | | | | | | | | | | | | | | | | | | | | | Form 610-D | | | | | | | | | | | | SERVICE | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | ELEV: |
| 1950 | | | | / | / | / | / | / | / | / | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 51 | X | X | X | X | X | X | X | X | X | X | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 52 | X | / | X | X | X | X | X | X | / | X | X | X | | | | | | | | | | | | | | | | | | | / | X | / | | | | | |
| 53 | X | / | / | X | X | / | X | / | / | X | X | / | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 54 | / | / | / | / | X | / | X | X | X | X | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 55 | X | / | / | X | X | X | X | X | X | X | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 56 | X | / | X | X | X | X | / | / | / | / | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 57 | / | X | X | X | / | / | / | / | X | X | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | 11/5/59 |
| 58 | X | X | X | X | / | / | X | X | / | | / | / | | | | | | | | | | | | | | | | | | | | | | | | | | Form 610-8 began |
| 59 | X | X | X | X | X | X | / | / | X | / | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1960 | X | / | / | X | / | / | X | X | / | / | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 61 | | / | / | X | X | X | X | / | / | X | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 62 | X | X | X | X | X | X | X | X | X | / | X | / | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 63 | X | X | / | / | X | / | X | / | X | X | X | / | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 64 | X | X | X | X | / | X | X | X | X | / | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 65 | X | X | X | X | X | X | / | X | / | / | / | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 66 | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

CROSS - REFERENCE -

the tapes were transcribed into a station log which is included as Appendix I to the present report. A comparison of this data with the available daily total global insolation data on the 480 Series computer compatible magnetic tapes revealed no major discrepancies but did provide information about those months which might contain questionable data. As a result, it was decided to use the 480 Series data as qualified by the logs as a basis for the SMY selection procedure described in the next section.

## 3.0 Model Year Selection Procedure

As discussed in Section 1.0, the primary objective of the present work is to develop a model year that will adequately represent the solar radiation that might be expected at the proposed experiment site. In this respect, two essential features must be included in the model: (i) the average characteristics should agree closely with the long-term averages for the site, and (ii) the day-to-day variability in the model should be similar to that at the site. These aspects are, of course, simply a statement of the requirement that the model year match the long term data in a weak statistical sense. For the model and long term data to be strictly equivalent in the statistical sense, one would have to match not only the means but also all of the higher moments of the various distributions. From a practical point of view the latter approach is not easily carried out and one must resort to a weaker match. In the case of a general meteorological model year there are a variety of parameters that must be matched in a statistical sense to the long term characteristics (e.g., insolation, temperatures, wind characteristics, cloud cover, precipitation) and the selection procedures can become quite involved. However, if one is concerned primarily with the solar radiation characteristics, this selection procedure can be considerably simplified by basing it on these features alone. The problem thus reduces to suitably matching the solar radiation characteristics, namely the daily total global insolation in the present case, so that these features in the model year are statistically similar to what are observed at the site over extended periods of time.

It has been tacitly assumed from the outset that this matching procedure would be applied to data sequences of one year. This is a somewhat arbitrary assumption since there obviously are year-to-year variations in the data as well. However, the concept of using a single year model is based largely on the practical matter of economics and the realization that from a solar energy utilization point of view, the most pronounced variati ons in the data occur over yearly periods of time. Attempts to construct "typical" models spanning several years would likely provide little improvement from a solar energy engineering point of view over a simpler single year model. In constructing a single year model, however, one is immediately faced with the problem of maintaining on a seasonal basis (e.g., winter, spring, summer, fall) a suitable match with the long-term characteristics. It is, for example, quite possible to have an usually cloudy summer followed by an average or a clearer than average winter. One approach to handling this problem is simply to discard in succession the most extreme years until one is left with the "least extreme" year. Another method is to construct a pseudo year by selecting the least extreme or otherwise most suitable seasons or even months from among all these available. This type of model obviously will lose some of its internal consistency as a result of combining data from widely different years (this would be most obvious in the autocorrelation function).

The approach used in the present work is to construct a pseudo year on a monthly basis by selecting the most suitable months from among all of the same months for which data is available. When the 12 months are assembled into the model year, the month-to-month transition is adjusted to occur at midnight when the insolation is zero and any critical parameters, in particular the dry bulb temperature and dew point are smoothed over the adjacent one or 3 hours (depending on the frequency of measurement). This approach has been taken for the following reasons.

(1) The seasonal insolation characteristics generally are of critical importance in simulating the annual performance of solar systems and this method insures that the model year will have most nearly average characteristics on a seasonal basis.

(2) The available data base is not entirely complete so that it would be very difficult to select an actual year without at the same time including a certain amount of missing data. On the other hand, if only complete years were taken as a basis, this would severly limit the ability to construct the most suitable match.

(3) Use of monthly segments of data represents a convenient compromise between the desire to use only complete sets of data and the need to minimize the number of potential discontinuities in the data.

(4) Since the model year will be used primarily for simulating solar system performance with loads that are not strongly related to other meteorological variables, the 12 midnight discontinuities are not expected to present significant problems.

The actual selection procedure for picking the 12 typical months from among the 20 years of available data has been based on making a weak statistical match with the long term characteristics. That is, the individual months are selected in each case by matching as closely as possible the month mean daily total global insolation and its variance over that month with the average monthly means and variances taken over all the months for which data are available. In the latter averaging, the monthly data are weighted in proportion to the amount of data available (i.e., months with missing data are given less weight).

The daily total global insolation data were obtained from the 480 series NCC tape for Atlanta which covers the years 1952-1974. A table of monthly means and variances, the long-term averages for each month, and the yearly averages for each year was prepared. The data arranged in a matrix format is shown in Table 2. Each year is represented by a group of 3 rows which in the first 12 columns give for each month the mean and the

TABLE 2. Matrix of Monthly Means and Standard Deviations of the Daily Total Global Insolation for Atlanta

| MONTH - | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | YEAR AVE'S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR 52 | | | | | | | | | | | | | |
| MEAN | 0 | 0 | 0 | 0 | 0 | 0 | 555 | 420 | 461 | 389 | 265 | 218 | 352 |
| STD DEV | 0 | 0 | 0 | 0 | 0 | 0 | 124 | 146 | 135 | 128 | 119 | 104 | 123 |
| QUALITY | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | .29 | .55 | .90 | .87 | 1.00 | 1.00 | .77 |
| YEAR 53 | | | | | | | | | | | | | |
| MEAN | 215 | 294 | 403 | 553 | 562 | 582 | 543 | 588 | 462 | 410 | 279 | 213 | 419 |
| STD DEV | 114 | 137 | 209 | 207 | 198 | 171 | 139 | 103 | 176 | 101 | 96 | 118 | 147 |
| QUALITY | 1.00 | .90 | .84 | .83 | .84 | .80 | .97 | .68 | .90 | .84 | .83 | .81 | .85 |
| YEAR 54 | | | | | | | | | | | | | |
| MEAN | 240 | 327 | 456 | 513 | 592 | 676 | 583 | 540 | 470 | 386 | 256 | 210 | 441 |
| STD DEV | 108 | 134 | 155 | 203 | 211 | 132 | 82 | 91 | 111 | 89 | 128 | 97 | 126 |
| QUALITY | .74 | .55 | 1.00 | .60 | 1.00 | .93 | .87 | 1.00 | 1.00 | 1.00 | 1.00 | .97 | .89 |
| YEAR 55 | | | | | | | | | | | | | |
| MEAN | 216 | 276 | 373 | 507 | 534 | 583 | 496 | 528 | 361 | 354 | 285 | 193 | 391 |
| STD DEV | 126 | 140 | 182 | 175 | 162 | 133 | 113 | 92 | 136 | 101 | 106 | 96 | 130 |
| QUALITY | 1.00 | .90 | .97 | 1.00 | .97 | 1.00 | 1.00 | .81 | .97 | .90 | 1.00 | .97 | .96 |
| YEAR 56 | | | | | | | | | | | | | |
| MEAN | 240 | 247 | 416 | 518 | 543 | 575 | 0 | 0 | 0 | 290 | 305 | 237 | 367 |
| STD DEV | 100 | 164 | 163 | 185 | 159 | 110 | 0 | 0 | 0 | 101 | 114 | 112 | 139 |
| QUALITY | 1.00 | .86 | 1.00 | 1.00 | 1.00 | .33 | 0.00 | 0.00 | 0.00 | .23 | .97 | 1.00 | .82 |
| YEAR 57 | | | | | | | | | | | | | |
| MEAN | 226 | 294 | 365 | 521 | 527 | 524 | 602 | 568 | 332 | 328 | 231 | 218 | 400 |
| STD DEV | 115 | 144 | 214 | 173 | 175 | 153 | 134 | 99 | 179 | 136 | 120 | 102 | 145 |
| QUALITY | .84 | .83 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | .80 | .90 | 1.00 | 1.00 | .95 |

TABLE 2 (Continued)

| MONTH | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | YEAR AVE'S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR 58 | | | | | | | | | | | | | |
| MEAN | 240 | 365 | 344 | 427 | 537 | 547 | 527 | 509 | 446 | 355 | 264 | 229 | 394 |
| STD DEV | 103 | 147 | 168 | 186 | 154 | 148 | 94 | 98 | 153 | 131 | 108 | 106 | 134 |
| QUALITY | 1.00 | .90 | 1.00 | 1.00 | 1.00 | .73 | .55 | 1.00 | 1.00 | 1.00 | .77 | .90 | .91 |
| YEAR 59 | | | | | | | | | | | | | |
| MEAN | 219 | 236 | 392 | 455 | 498 | 552 | 484 | 472 | 378 | 262 | 269 | 192 | 373 |
| STD DEV | 117 | 152 | 185 | 199 | 145 | 114 | 116 | 90 | 128 | 147 | 105 | 91 | 132 |
| QUALITY | .55 | .97 | 1.00 | 1.00 | 1.00 | .97 | 1.00 | 1.00 | .93 | .94 | .97 | 1.00 | .94 |
| YEAR 60 | | | | | | | | | | | | | |
| MEAN | 200 | 304 | 344 | 430 | 503 | 487 | 461 | 449 | 366 | 323 | 271 | 217 | 362 |
| STD DEV | 126 | 185 | 175 | 166 | 124 | 95 | 106 | 108 | 138 | 103 | 106 | 92 | 125 |
| QUALITY | .97 | 1.00 | .58 | 1.00 | 1.00 | 1.00 | .94 | .84 | .97 | 1.00 | .93 | .97 | .93 |
| YEAR 61 | | | | | | | | | | | | | |
| MEAN | 280 | 239 | 334 | 492 | 490 | 480 | 553 | 438 | 445 | 398 | 242 | 165 | 388 |
| STD DEV | 63 | 158 | 158 | 176 | 206 | 179 | 108 | 150 | 88 | 82 | 96 | 111 | 135 |
| QUALITY | .48 | .97 | .94 | 1.00 | 1.00 | 1.00 | 1.00 | .97 | 1.00 | .94 | .73 | .97 | .92 |
| YEAR 62 | | | | | | | | | | | | | |
| MEAN | 184 | 305 | 387 | 489 | 625 | 583 | 585 | 546 | 441 | 412 | 253 | 217 | 413 |
| STD DEV | 111 | 145 | 177 | 163 | 66 | 142 | 129 | 85 | 152 | 108 | 128 | 103 | 123 |
| QUALITY | 1.00 | .86 | .90 | .33 | .87 | 1.00 | .97 | 1.00 | 1.00 | .97 | 1.00 | 1.00 | .91 |
| YEAR 63 | | | | | | | | | | | | | |
| MEAN | 218 | 342 | 442 | 506 | 568 | 511 | 575 | 485 | 390 | 429 | 265 | 232 | 413 |
| STD DEV | 119 | 147 | 202 | 201 | 168 | 223 | 144 | 127 | 132 | 84 | 114 | 106 | 146 |
| QUALITY | .97 | .93 | 1.00 | .83 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | .98 |
| YEAR 64 | | | | | | | | | | | | | |
| MEAN | 217 | 286 | 397 | 425 | 556 | 592 | 474 | 485 | 425 | 356 | 274 | 176 | 390 |
| STD DEV | 123 | 147 | 203 | 225 | 170 | 122 | 169 | 144 | 151 | 142 | 98 | 90 | 149 |
| QUALITY | 1.00 | 1.00 | 1.00 | .97 | 1.00 | .97 | 1.00 | 1.00 | .97 | 1.00 | .97 | .84 | .98 |

ABLE 2 (Continued)

| ONTH | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | YEAR AVE'S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EAR 65 | | | | | | | | | | | | | |
| EAN | 252 | 284 | 312 | 483 | 616 | 472 | 509 | 502 | 382 | 365 | 240 | 235 | 389 |
| TD DEV | 103 | 154 | 182 | 169 | 101 | 176 | 116 | 93 | 152 | 124 | 108 | 98 | 129 |
| UALITY | .94 | .93 | .77 | 1.00 | 1.00 | .83 | .97 | 1.00 | .90 | 1.00 | .97 | 1.00 | .94 |
| EAR 66 | | | | | | | | | | | | | |
| EAN | 193 | 246 | 451 | 458 | 481 | 580 | 476 | 451 | 393 | 312 | 235 | 202 | 373 |
| TD DEV | 124 | 161 | 158 | 152 | 223 | 126 | 169 | 130 | 143 | 154 | 101 | 97 | 144 |
| JALITY | 1.00 | .93 | 1.00 | 1.00 | 1.00 | 1.00 | .97 | .97 | 1.00 | .97 | 1.00 | 1.00 | .99 |
| EAR 67 | | | | | | | | | | | | | |
| EAN | 212 | 272 | 405 | 495 | 497 | 477 | 485 | 427 | 409 | 345 | 258 | 167 | 370 |
| TD DEV | 105 | 156 | 139 | 164 | 213 | 170 | 133 | 157 | 137 | 128 | 124 | 95 | 143 |
| JALITY | .97 | .97 | .94 | 1.00 | 1.00 | 1.00 | 1.00 | .94 | .97 | 1.00 | 1.00 | 1.00 | .98 |
| EAR 68 | | | | | | | | | | | | | |
| EAN | 183 | 307 | 446 | 418 | 520 | 567 | 492 | 495 | 384 | 298 | 222 | 197 | 376 |
| TD DEV | 118 | 127 | 115 | 200 | 159 | 135 | 137 | 130 | 114 | 126 | 109 | 96 | 130 |
| UALITY | 1.00 | .97 | .74 | 1.00 | 1.00 | 1.00 | .97 | 1.00 | .97 | 1.00 | .97 | 1.00 | .97 |
| EAR 69 | | | | | | | | | | | | | |
| EAN | 167 | 245 | 387 | 446 | 473 | 489 | 0 | 0 | 376 | 327 | 275 | 193 | 332 |
| TD DEV | 100 | 146 | 162 | 186 | 182 | 116 | 0 | 0 | 128 | 108 | 82 | 109 | 132 |
| JALITY | 1.00 | .97 | 1.00 | 1.00 | 1.00 | .87 | 0.00 | 0.00 | .30 | .87 | 1.00 | 1.00 | .90 |
| EAR 70 | | | | | | | | | | | | | |
| EAN | 236 | 324 | 347 | 441 | 538 | 501 | 517 | 439 | 429 | 275 | 240 | 192 | 379 |
| TD DEV | 115 | 125 | 170 | 184 | 191 | 149 | 128 | 123 | 87 | 134 | 130 | 101 | 137 |
| JALITY | .39 | .97 | 1.00 | 1.00 | 1.00 | .90 | 1.00 | 1.00 | .97 | 1.00 | 1.00 | 1.00 | .93 |
| EAR 71 | | | | | | | | | | | | | |
| EAN | 192 | 284 | 385 | 526 | 582 | 556 | 443 | 444 | 372 | 282 | 275 | 158 | 374 |
| TD DEV | 114 | 146 | 201 | 163 | 172 | 110 | 133 | 109 | 128 | 143 | 87 | 82 | 132 |
| UALITY | 1.00 | .97 | 1.00 | .93 | .97 | 1.00 | 1.00 | 1.00 | .97 | .97 | .93 | 1.00 | .98 |

TABLE 2 (Continued)

| MONTH - | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | YEAR AVE'S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR 72 | | | | | | | | | | | | | |
| MEAN | 174 | 216 | 370 | 483 | 437 | 496 | 455 | 413 | 334 | 252 | 168 | 124 | 326 |
| STD DEV | 108 | 132 | 154 | 124 | 134 | 158 | 94 | 73 | 79 | 94 | 96 | 82 | 110 |
| QUALITY | 1.00 | 1.00 | .97 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| YEAR 73 | | | | | | | | | | | | | |
| MEAN | 156 | 228 | 235 | 392 | 0 | 515 | 455 | 415 | 333 | 287 | 204 | 168 | 292 |
| STD DEV | 88 | 105 | 145 | 162 | 0 | 130 | 92 | 91 | 108 | 116 | 85 | 86 | 107 |
| QUALITY | .94 | .93 | 1.00 | .87 | 0.00 | .30 | .90 | 1.00 | .97 | .94 | 1.00 | .90 | .89 |
| YEAR 74 | | | | | | | | | | | | | |
| MEAN | 0 | 0 | 0 | 0 | 0 | 0 | 499 | 385 | 327 | 446 | 0 | 0 | 371 |
| STD DEV | 0 | 0 | 0 | 0 | 0 | 0 | 143 | 111 | 146 | 41 | 0 | 0 | 125 |
| QUALITY | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | .19 | 1.00 | 1.00 | .10 | 0.00 | 0.00 | .57 |
| YEAR 99 | | | | | | | | | | | | | |
| MEAN | 208 | 280 | 380 | 473 | 532 | 539 | 511 | 475 | 396 | 339 | 252 | 197 | 377 |
| STD DEV | 110 | 144 | 172 | 178 | 165 | 143 | 123 | 111 | 130 | 117 | 107 | 98 | 131 |
| QUALITY | .89 | .92 | .94 | .92 | .98 | .89 | .88 | .94 | .93 | .89 | .96 | .97 | .91 |

standard deviation of the daily total global insolation in Ly/day along with the fraction of days for which data are available. The 13th column contains the average of the means (the annual mean) and average of the standard deviations (not the annual standard deviation) for that year. Also included is the annual fraction of data available which provides an overall measure of the data completeness. The last row entry in the matrix which is labeled year 99 contains entries for each month (column) that are determined in the same manner as for the 13th column but are for a particular month rather than for a year.

It is possible with reference to Table 2 to select the most representative months using as criteria.

(1) The monthly mean most nearly matches the long term averages for that month.

(2) The monthly variance or the standard deviation most nearly matches the long term averages for that month.

(3) The month contains a minimum of missing days.

Consideration was given to developing an optimization routine to select the months automatically, but eventually it was decided that the selection could be clearly made by hand with reference to Table 2 and the additional data qualifications in Appendix I. Thus, the objective in using the above criteria is to match as closely as possible the first two moments of the distribution function for the solar data. No consideration is given to other meteorological data (e.g., ambient temperature) and therefore, the resultant model year values for these data may not agree either with long term averages or with other modesl (TRY, etc.). Using the above criteria, the months shown in Table 3 were selected.

TABLE 3. Model Year Months Selected

And Their Comparison to Long Term Averages

| Model Month | Year Selected | Mean* | Mean Ratio** | Std. Dev.* | Std. Dev. Ratio** |
|---|---|---|---|---|---|
| Jan. | 1953 | 215 | 1.03 | 114 | 1.04 |
| Feb. | 1971 | 284 | 1.01 | 146 | 1.01 |
| Mar. | 1969 | 387 | 1.02 | 162 | 0.94 |
| Apr. | 1965 | 483 | 1.02 | 169 | 0.95 |
| May | 1957 | 527 | 0.99 | 175 | 1.06 |
| Jun. | 1957 | 524 | 1.03 | 153 | 1.07 |
| Jul. | 1970 | 517 | 0.99 | 128 | 1.04 |
| Aug. | 1959 | 472 | 0.99 | 90 | 0.81 |
| Sep. | 1963 | 390 | 0.98 | 132 | 1.02 |
| Oct. | 1967 | 345 | 1.02 | 128 | 1.09 |
| Nov. | 1967 | 258 | 1.02 | 124 | 1.16 |
| Dec. | 1970 | 192 | 0.97 | 101 | 1.03 |

* Means and std. dev. are in units of Langleys/day

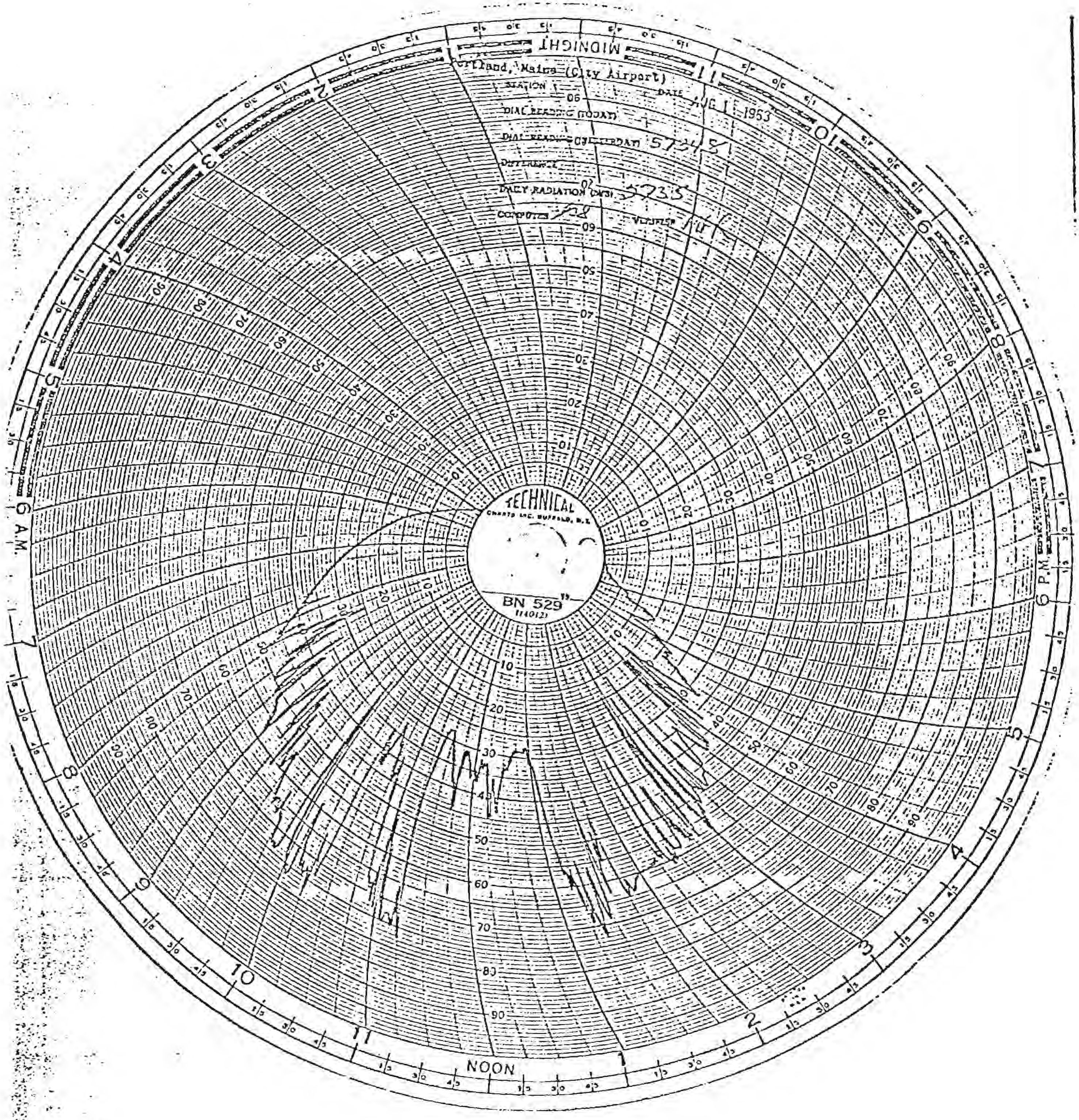
** Ratio is with respect to long term monthly values

## 4.0 Conversion to Computer Compatible Format

As outlined in Section 1.0, the next step in the generation of the SMY was to digitize the graphical data contained on each of the daily circular recorder charts for the selected model year months. This step was anticipated to be the most time consuming since hourly or more frequent digitization intervals were initially planned. Several aspects of the chart data, a sample of which is shown in Figure 1, appeared to present major problems. First, and most obvious is the nonlinear scale system employed on the charts. While the radial scale is almost linear, the time or angular scale is shifted as a function of radial position in order to accommodate the particular pen movement for that type of recorder. This would appear to complicate any attempt to use an automated digitization procedure, based for example on use of a cartesion coordinate digitizer. Secondly, the nature of the data on partly cloudy days is such that it is impossible to accurately represent the short period (5 min. or less) fluctuations in any practical manner. Finally, on some of the charts, these have been various adjustments, especially in the time position, that must be properly accounted for.

After considerable study of the problem and discussions with NCC personnel, a novel and efficient method was developed that would allow digitization of the charts to be made at 15 min. intervals. Since the charts are ruled in 15 min. increments, it is relatively simple to read off the radial coordinate where the trace crosses each of the time lines. In those cases where considerable fluctuations in the radiation occur, this process must be carried out largely by visual estimation. (It is encouraging that in many other similar instances, local visual estimation or averaging of chart data has yielded results that are in good agreement with more precise-and time consuming-methods.) This procedure yields a sequential record of radiation at 15 min. intervals relative to the starting hour. The procedure was significantly automated by use of NCC's HP9830 calculator and flat-bed cartesian digitizer

Figure 1. Typical Circular Chart from a NWS Station



which allowed the actual coordinates to be read and stored on cassette tapes. Since the data are taken sequentially, one only needs to know the starting hour and the insolation can be computed from the radial distance of the point from the origin which is defined to be at the chart center.

A visit was made to NCC and in 3 man-days the selected charts were digitized and stored on cassette tapes. Xerox copies of all digitized charts were also obtained for reference. After some exploration, a 9830 calculator with suitable peripherals to allow copying the cassettes to Georgia Tech's CDC computer mainframe was located in Albany, Georgia. A rental arrangement was worked out and the machine was used to read the cassettes and transmit the data over the phone to the campus computer.

Next, an extensive period of data verification was carried out. Using digitized data a copy of each chart was constructed on a graphics terminal, and the result was compared to the Xerox chart copy. Any shifts or discrepancies were removed by editing. Then, each chart record was scaled and numerically integrated and the resultant daily total was compared to the tabulated NCC value (from the ball-and-disc integrator in the site recorder). If a discrepancy of 2% or more was found, the chart data was reexamined and adjusted if possible. (A bad integrator reading was found in one case!) Finally, the data were corrected for any problems noted on the charts and the results stored in computer files.

## 5.0 Instrument Rehabilitation

It has been widely recognized that insolation data from the old NWS network of stations is subject to significant errors as a result of degradation in the characteristics and therefore in the calibration of the pyronameters used. A comprehensive program of rehabilitation of the data from many of these stations, including Atlanta, is currently underway within NOAA, and initially in the present study an attempt was made to obtain this information for the Atlanta Airport station. Unfortunately, the timing of the studies was not in line and it was therefore not possible to obtain the instrument correction factors in time to complete the present work. As a result, an alternate approach was taken and the rehabilitation was carried out using information extracted directly from the Atlanta 480 series tape data.

The present rehabilitation method is based on a regression analysis of the performance of each instrument under clear sky conditions over its lifetime. It is similar to a method proposed by Martin, Berdahl, et. al.* and provides a realistic means for correcting for an observed downward trend in insolation data as time passes. The available information is taken as the daily total global insolation data on the 480 series tape along with the station instrument logs, a copy of which is included in Appendix II. Because the data for a given instrument is in some cases limited, an attempt has been made to exclude systematic, periodic or random effects as follows:

1. Unless the instrument was used for 3 or more years, no correction attempt was made.
2. To exclude weather effects to the maximum extent possible, only the data for the clearest day out of 40 day intervals are used. This is defined for the present data as the day with the greatest percent of possible insolation (presumably only a clear day).

*Martin, M., Berdahl, P., et. al., "Rehabilitation Techniques for Daily Solar Radiation Data", Proc. of the 1977 Annual Meeting, American Section of the Inter. Solar Energy Society, Orlando, Florida, June 1977.

3. To exclude seasonal effects, only full years are considered.

The actual procedure can be outlined in a brief manner as follows. First, the data covering the desired period of operation (1952-1974) are examined and the clearest day total global insolation for each 40 day interval is selected. Figure 2 shows a portion of a typical plot of these data when expressed as a percent of the possible extraterrestrial radiation. The figure shows clearly the seasonal variation as well as a yearly reduction which is especially evident in the peak values. Next, the annual means of the "clear day" data in Figure 2 are complied and a linear regression analysis is carried out to determine the long term degradation over the years of operation for each instrument. Figure 3 shows examples of these data for several instruments along with the slope and intercept of the linear regression line. The degradation can thus be expressed as

$$y = b_0 + b_1 x$$

where

$y$ = annual mean percent of possible daily total global insolation

$x$ = years since instrument installation

$b_0, b_1$ = linear regression coefficients.

Using this, the pyronaometer response is deduced to degrade in a linear manner as:

$$C = C_0 \left(1 + \frac{b_1}{b_0} x\right)$$

where

$C$ = current response

$C_0$ = calibrated response.

Since the parameter, $b_0$, is an extrapolation to a presumed condition, it was felt that a better normalization factor above would be the average annual means, $\langle y \rangle$. This yields:

$$C = C_0 \left(1 + \frac{b_1}{\langle y \rangle} x\right) = C_0/f$$

where f is the fractional annual degradation. While these parameters are derived based on daily totals of insolation, it is reasonable to assume that they apply as

Figure 2
"COMPRESSED" PERCENT OF "ETR" PLOT FOR
ATLANTA, GA. FROM 1952 - 1974

```
                           50   55   60   65   70   75   80   85   90   95  100
% ETR   ABSDAY YEAR J. DAY +----+----+----+----+----+----+----+----+----+----+
   65      223   53     39 ****************    I    I    I    I    I    I    I
   85      248   53     64 ************************************    I    I    I
   90      301   53    117 *****************************************    I    I
   90      334   53    150 *****************************************    I    I
   86      346   53    162 *************************************   I    I    I
   86      397   53    213 *************************************   I    I    I
   86      440   53    256 *************************************   I    I    I
   74      486   53    302 *************************I    I    I    I    I    I
   57      544   53    360 ********  I    I    I    I    I    I    I    I    I
   55      549   53    365 XXXXXX    I    I    I    I    I    I    I    I    I
   67      589   54     40 ******************  I    I    I    I    I    I    I
   87      623   54     74 **************************************  I    I    I
   92      656   54    107 *******************************************  I    I
   95      690   54    141 **********************************************    I
   90      724   54    175 *****************************************    I    I
   83      771   54    222 ********************************** I    I    I    I
   81      792   54    243 ********************************   I    I    I    I
   69      839   54    290 ********************I    I    I    I    I    I    I
   69      879   54    330 ********************I    I    I    I    I    I    I
   52      913   54    364 XXX  I    I    I    I    I    I    I    I    I    I
   99      940   55     26 **************************************************I
   78      995   55     81 ***************************** I    I    I    I    I
   85     1000   55     86 ************************************    I    I    I
   89     1065   55    151 ****************************************I    I    I
   83     1095   55    181 ********************************** I    I    I    I
   80     1139   55    225 *******************************    I    I    I    I
   77     1172   55    258 ****************************  I    I    I    I    I
   74     1196   55    282 *************************I    I    I    I    I    I
   58     1247   55    333 ********* I    I    I    I    I    I    I    I    I
   54     1279   55    365 XXXXXI    I    I    I    I    I    I    I    I    I
   96     1314   56     35 ***********************************************   I
   81     1347   56     68 ********************************   I    I    I    I
   89     1397   56    108 ****************************************I    I    I
   88     1434   56    155 *************************************** I    I    I
   56     1441   56    162 *******   I    I    I    I    I    I    I    I    I
    0     1520   56    241 I    I    I    I    I    I    I    I    I    I    I
    0     1560   56    281 I    I    I    I    I    I    I    I    I    I    I
   70     1580   56    301 *********************    I    I    I    I    I    I
   65     1606   56    327 ****************    I    I    I    I    I    I    I
   58     1643   56    364 XXXXXXXXX I    I    I    I    I    I    I    I    I
   65     1663   57     18 ****************    I    I    I    I    I    I    I
   86     1724   57     79 *************************************   I    I    I
   92     1741   57     96 *******************************************  I    I
   89     1771   57    126 ****************************************I    I    I
   88     1833   57    188 *************************************** I    I    I
   86     1864   57    219 *************************************   I    I    I
   79     1889   57    244 ******************************I    I    I    I    I
   71     1932   57    287 **********************   I    I    I    I    I    I
   61     1969   57    324 ************   I    I    I    I    I    I    I    I
```

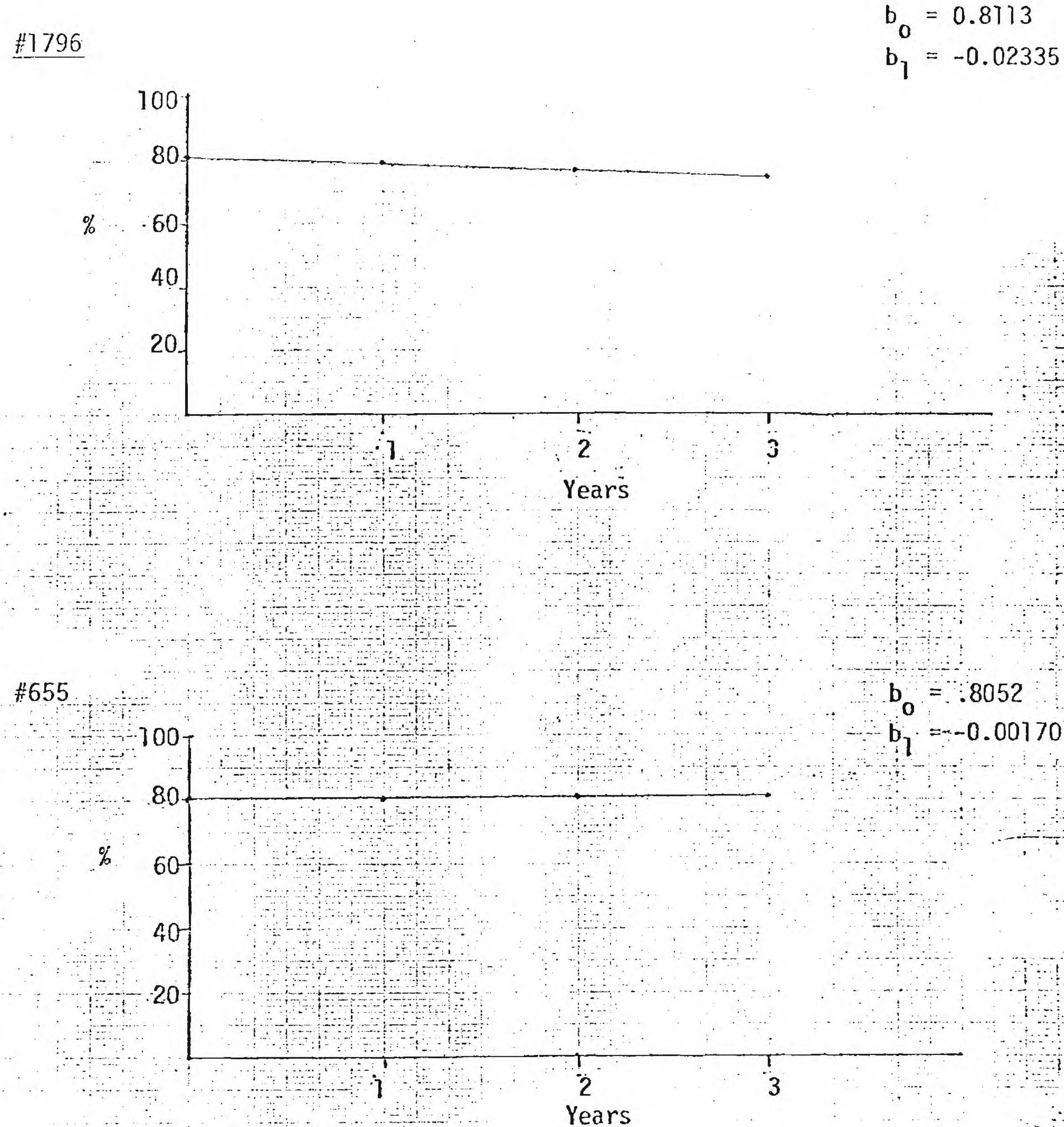
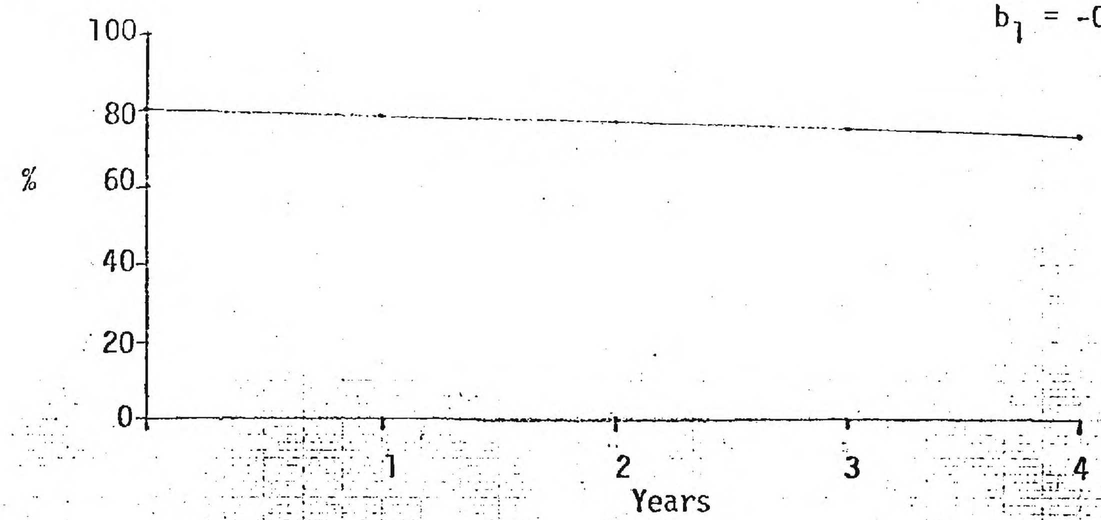



Figure 3. Annual Average of Maximum Percent-Possible Daily Solar Irradiation (PP = TH/TE) over 40 day intervals for each year of instrument operation.

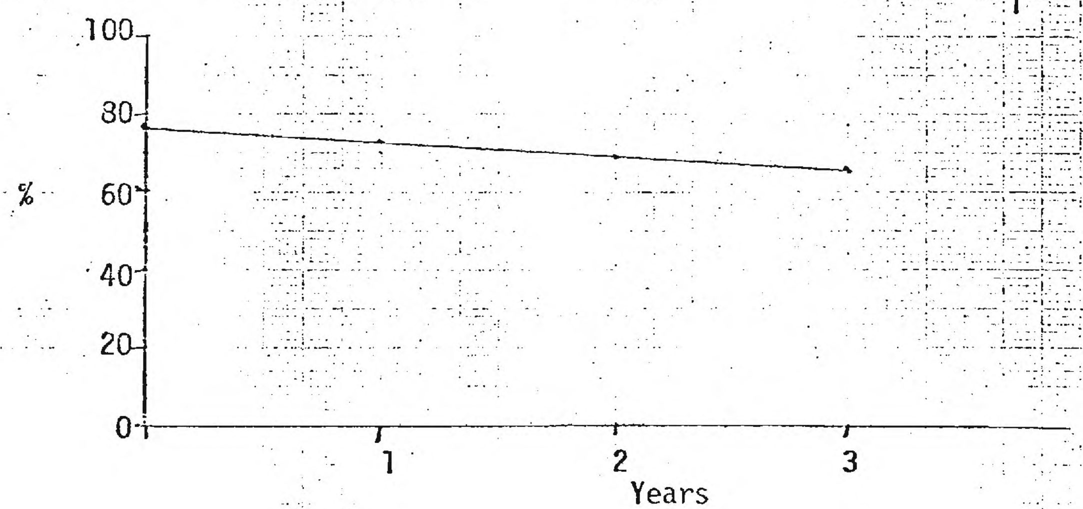
#2599

$b_o$ = .8023
$b_1$ = -0.01839




#1610

$b_o$ = .7677
$b_1$ = -0.03670




(Figure 3 contd) Annual Average of Maximum Percent-Possible Daily Solar Irradiation (PP = TH/TE) over 40 day intervals for each year of instrument operation.

well to the instantaneous instrument response. Thus, if given an observed pyranometer output, $I_o$, the actual reading, $I_a$, can be deduced as:

$$I_a = I_o f$$

where the argument x in the definition of f is taken to be the number of years the instrument has been in ooeration measured to the mid-point of the month in question.

Table 4 shows final results of applying this procedure to the SMY data. A total of 4 instruments are covered, however #655 which is not shown in Table 4 exhibited no measurable degradation and listed as N.C. for "no change". Also, insufficient data were available to correct January 1953 data. The factor, f, from Table 4 has been used to adjust the 15 minute data incorporated into the SMY.

## TABLE 4

### PYRANOMETER CORRECTION TABLE

| | Instrument | $b_1$ | $\langle y \rangle$ | x (years) | f | Year |
|---|---|---|---|---|---|---|
| January | N.C. | | | | | 1953 |
| February | 1610 | .03670 | .7126 | 1.00 | 1.0515 | 1971 |
| March | N.C. | | | | | 1964 |
| April | 2599 | .01839 | .7655 | 0.14 | 1.0034 | 1965 |
| May | 1796 | .02335 | .7763 | 0.52 | 1.0156 | 1957 |
| June | 1796 | .02335 | .7763 | 0.61 | 1.0183 | 1957 |
| July | 1610 | .03670 | .7126 | 0.42 | 1.0216 | 1970 |
| August | 1796 | .02335 | .7763 | 2.78 | 1.0836 | 1957 |
| September | N.C. | | | | | 1963 |
| October | 2599 | .01839 | .7655 | 2.64 | 1.0634 | 1967 |
| November | 2599 | .01839 | .7655 | 2.73 | 1.0656 | 1967 |
| December | 1610 | .03670 | .7126 | 0.92 | 1.0474 | 1970 |

$$f = \left(1 + \frac{b_1}{\langle y \rangle} x\right)^{-1}$$

x = years since installation

## 6.0 Final Model Year Assembly

The procedures described in the preceeding sections yield the solar radiation data values for the SMY. The radiation data must finally be supplemented with related meteorological measurements and combined to form the complete SMY. In addition, the global insolation data obtained directly from the circular charts can be further decomposed into beam and diffuse components. This has been done for the present SMY and the results converted into a 15 min. SOLMET format consisting of the standard 163 character records but in the present case scaled for 15 min. rather than the standard hourly intervals.

The meteorological data were obtained from the NCC TDF-14 series of surface observations for the Atlanta Airport station. The only notable problem in this approach is the variation in frequency of observation since in 1965 the NWS changed from hourly to 3-hourly observations. The specific data added are as follows

- Surface observation time
- Ceiling
- Sea level and station pressure
- Dry bulb temperature
- Dew point temperature
- Wind direction
- Wind speed.

In addition, since the chart insolation data are in solar time, the corresponding local standard times were computed.

The decomposition of global insolation into beam and diffuse components was carried out by Dr. Charles Randall of the Aerospace Corporation using methods developed by him. This approach was taken in preference to earlier methods (e.g., that due to Liu and Jordan) because the present method is based on more representative data and includes a random component to more closely approximate the actual behavior.

This SMY for the Atlanta-Shenandoah region is currently available in SOLMET, 7 or 9 track, 556, 800, or 1600 bpi density format as Release 2. (This supercedes Relase 1 which included the Liu and Jordan decomposition, did not include the eccentricity term in the solar-local time conversion, and contained two months with surface observations of 6 hour intervals.)

# APPENDIX I

Log of NCC Chart Data for Atlanta

As Obtained from Visual Inspection

Station: Atlanta
Year: 1973

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| January | 12 | Bad | |
| | 14 | Bad | |
| | 15 | | Time adjustment |
| February | 28 | Missing 0800-1000 | |
| March | | No Faults | |
| April | 23 | No afternoon data | |
| | 24 | No afternoon data | New Epply serial #7544 constant 1.77, 1308 |
| | 26 | | Used old pyranometer only |
| May | 23-31 | Missing | |
| June | 1-7 | Missing | |
| | 8 | Missing morning through 1430 | |
| | 13 | | Out of service 0900-1100, 1100 to 1430 |
| | 18 | | Out of service 0800-1130 |
| | 19 | | Out of service 1500-1800 |
| | 29 | Missing | |
| | 30 | Missing | |
| July | 1 | Missing | |
| | 2 | Missing | |
| | 3 | Missing morning through 1415 | |
| August | | No Faults | |
| September | | No Faults | |
| October | 18 | Missing 1100 through 1200 | |
| November | | | Honeywell Charts |
| December | 2 | Missing 1330 through 1445 | |
| | 4 | Out of range from 1000 to 1100 | |
| | 6 | | Data erratic - note on chart says clear all day |
| | 9 | | No data from 1130 to 1200 |
| | 30 | | No data until 1600 |
| | 31 | | Data too high |

Station: Atlanta
Year: 1954 (Continued)

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| July | 6 | | Out of service for calibration until 1330 |
| | 8 | | Out of service until 1130 |
| | 9 | | No good data for whole day, chart slipped |
| August | | No Faults | |
| September | 14 | | Ran out of ink at 1315 |
| | 28 | | Chart legible from 1100-1500 |
| | 29 | | Pen was running out of ink or clogged very hard to read between 0900-1100 |
| October | | No Faults | |
| November | | No Faults | |
| December | | No Faults | |

Station: Atlanta
Year: 1955

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| January | | No Fault | |
| February | 15 | | Out of service from 0815-rest of day |
| | 16 | | Not in service until 1400 |
| | 18 | | Illegible from 1100 on |
| | 19 | Missing | |
| | 20 | Missing | |
| | 21 | | Illegible |
| | 22 | Missing | |
| | 23 | Missing | |
| | 24-28 | Missing | |
| March | | No data until March 15 | |
| April | | No Faults | |
| May | | No Faults | |
| June | | No Faults | |
| July | | No Faults | |
| August | 26 | | Clock out of calibration all day, solar readings seem to be in tact |
| | 27 | | Clock reset, readings from 0900-on |
| September | 4 | | Power failure on readings from 1315-on |
| October | 10 | | Solar data bearly legible till 1000, no data after 1000 |
| | 11-12 | | Bearly legible |
| | 18 | | No data from 1100-on |
| November | | No Faults | |
| December | 1 | | No data from 1430 on - recorder failed |

Station: Atlanta
Year: 1951

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| January | 17 | Bad data 1320-1400 also 1430-1515 | |
| | 18 | Bad data 1415-1450 | |
| | 19 | Bad data 1015-1030 also 1040-1050, 1220-1300, 1450-1610 | |
| | 22 | No data | Machine was off for recalibration |
| | 24 | | 1345 timer reset to 1400 |
| | 25 | | Timer reset at 0840; reset to 0920 |
| | 29 | Bad data from 0830-0900 | |
| February | 19 | | Pen arm stuck from 1200 till 0400 |
| March | 5 | | Pen arm stuck between 1400-1800 |
| | 7 | | Pen stuck between 1130-1500 |
| April | 1 | Bad data from 1115-1320 | |
| | 12 | | Clock stopped at 0945 and was out the rest of the day |
| | 3 | | Pen ran out of ink from 1000-1330 |
| | 19 | | Pen stopped from 1330-1445 Pen stuck again from 1700-1845 |
| | 21 | Bad data from 1300-1320 | |
| | 22 | Bad data from 1130-1200 | |
| | 24 | Bad data from 1250-1340 | |
| | 27 | Bad data from 1030-1130 | |
| | 28-29 | | Recording instrument having problems, giving bad data for both days |
| | 30 | | Recording machine off from 1430-1440 |
| May | 4 | Bad data from 1215-1245 | |
| | 11 | Bad data from 1030-1130 | |
| | 15 | | Maintenance, dry cell changed |
| | 23 | | Off for maintenance from 1130-1200 |

Station: Atlanta
Year: 1951 (Continued)

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| June | | | Unusually deep trough in the radiation data as if something was completely blocking it from 1100-1300 |
| | 10 | | Data was not taken until 0900 as pen was not on arm |
| | 26 | | No data from 1000-night |
| July | 1 | Bad data from 1130-1345 | |
| | 3 | | Pen out of ink from 0900-1145 |
| | 8 | | No data from 1145-1500 |
| | 14 | | No data from 1115-1530 |
| | 20 | | No data from 1145-1445 |
| | 29 | | No data from 0900-1430 |
| | 30 | | Pen stuck between 1015-115 |
| August | | No Faults | |
| September | 11 | | Pen stuck between 1110-1240 |
| | 12 | | Pen stuck from 1015-1120 |
| | 21 | Bad data from 0745-0900 | |
| | 24 | | Pen stuck between 1045-1130 |
| October | 31 | | Battery changed between 0815-0845 |
| November | 15 | | Time corrected between 1115-1145 |
| December | 1 | | Time changed between 1400-1415 |
| | 8 | Bad data from 0945-1215 | |
| | 28 | Bad data from 1240-1415 | |

Station: Atlanta
Year: 1952

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| January | | No Faults | |
| February | 21 | | Pen stuck between 1015-1235 |
| | 25 | | Service by technican from 1030-1130 |
| | 29 | Bad data from 1130-1215 | |
| March | 5 | | Pen stuck from 1020-1120 |
| | 7 | | Pen stuck from 1030-1230 |
| | 11 | | Pen stuck from 0815-0830, 0900-0920, 0940-1020, 1040-1120 |
| | 21 | | Being serviced by technican 0945-1600 |
| April | 6 | | Pen sticking from 1030-1100, 1120-1200, 1210-1230, 1240-1400 |
| | 9 | No data from 1210-1240 | |
| | 18 | | Pen stuck from 1315-1345 and 1420-1445 |
| | 19 | | Pen stuck from 1400-1430 |
| | 20 | Bad data from 1445 on | |
| May | 4 | | Pen stuck from 1145-1330 |
| | 23 | | Pen sticking most of the day |
| June | 4 | | Pen sticking from 1345-1430 |
| | 8 | | Power failure from 0945-1030, Pen stuck from 1430-1530 |
| | 15 | | Pen stuck from 1240-1420 |
| | 17 | | Pen stuck from 1530-1620 |
| | 28 | | Pen stuck from 1330-1400 |
| July | 3 | | Pen out of ink from 1500-1545 |
| | 4 | | Pen out of ink from 0915-1130 |
| | 14 | | Pen stuck from 1330-1445 |
| | 16 | | Pen stuck from 1245-1345 |
| | 20 | Bad data from 1545 on | |
| | 21 | Bad data from 1400 on | |
| | 22 | | Pen sticking from 1415-1500 |
| | 26 | | Pen stuck from 1700-1800 |
| | 27 | | Pen sticking in various parts of the day for no more than 10 minutes at a time |
| | 28 | | Pen sticking from 1630-1700 |

Station: Atlanta
Year: 1952 (Continued)

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| August | 3 | | Pen sticking from 1345-1420, and 1430-1510, 1115-1215, 1430-1500, 1515-1540 |
| | 12 | | Pen stuck from 1340-1420 |
| | 14 | | Pen stuck from 1440-1530 |
| | 15 | | Pen stuck from 1530-1640 |
| | 18 | | Pen stuck from 1230-1520, and 1640-1730 |
| | 19 | | Pen sticking from 1000-1220 |
| | 20 | | Pen sticking from 1345-1815 |
| | 26 | | Pen stuck from 1330-1400 |
| | 28 | | Pen sticking from 1415-1500 |
| September | 2 | No data from 1020 on | |
| | 3 | No data until 0815 | |
| | 5 | No data from 0840-1115 | |
| October | 18 | Bad data from 0820-0830 | |
| | 20 | | Off for maintenance from 1245-1300 |
| November | | No Faults | |
| December | | No Faults | |

Station: Atlanta
Year: 1953

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| January | 5 | | Clock was 43 minutes fast at 0900 so it was set back to 0815 |
| February | 8 | No data until-1000 | |
| | 27 | | Pen stuck from 1640-1800 |
| March | 19 | | Battery changed from 0910-0920 |
| | 14 | | Pen stuck from 1245-1515 |
| | 15 | | Pen stuck from 1030-1240, 1315-1345 |
| | 18 | | Pen stuck from 1130-1330 |
| April | 1 | | Pen stuck from 1230-1320, and 1040-1110 |
| | 3 | No data from 0815-1110 | |
| | 2 | | Pen sticking from 1100-1315 |
| | 22 | No data from 0920-1430 | |
| May | 24 | No data from 0915-1315 | |
| June | 6 | | Pen sticking for 15 minute intervals between 0900-1000, 1000-1100 |
| | 8 | | Pen sticking for 5 to 10 minutes, 5 times |
| | 9 | | Pen stuck from 1200-1430 |
| July | 15 | Bad data from1420-1520 | |
| August | 5 | Data missing from 1300-1400 | |
| | 2 | Bad data from 0730-0915 | |
| | 10 | Bad data from 1045-1300 | |
| | 9 | Bad data from 1100-1420 | |
| | 21 | No data from 1515-1600 | |
| September | 2 | No data from 1040-1140 | |
| | 12 | | Pen stuck from 0730-0830 |

Station: Atlanta
Year: 1953 (Continued)

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| October | 20 | Bad data from 1140-1240 | |
| | 16 | BAd data from 1245-1430 | |
| November | 7 | No data from 1015-1045 | |
| | 18 | Bad data from 1030-1045 | |
| December | 8 | | Pen stuck from 1015-1045 and 1320-1350 |
| | 6 | | Pen stuck from 1330-1615 |
| | 4 | | Pen stuck from 1330-1730 |
| | 15 | Data missing from 0800-0845 | |
| | 12 | Data missing from 1445-1530 | |

Station: Atlanta
Year: 1954

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| January | 13 | Bad data from 1200-1300 | |
| | 19 | Bad data from 1100-1200 | |
| | 25 | Bad data from 0845-0915 | |
| | 23 | | Pen stuck from 1115-1500 |
| | 23 | | Pen stuck from 1215-1400 |
| | 30 | Bad data from 1430-1600 | |
| February | 6 | Bad data from 1245-1520 | |
| | 15 | Bad data from 1440-1510 | |
| | 17 | Bad data from 1440-1510 | |
| | 18 | Bad data from 1410 | |
| | 19 | | Pen stuck from 1430-1500 |
| | 21 | | Pen stuck from 1015-1115, 1310-1445, 1700-1815 |
| | 22 | | Pen stuck from 1230-1310 and 1700-1830 |
| | 23 | | Pen stuck from 1520-1615 |
| | 25 | Bad data from 1350-1430 and 1030-1200 | |
| March | | No faults | |
| April | 4 | | Pen sticking from 1245-1340 |
| | 10 | | Pen sticking from 1145-1300, and 1340-1500 |
| | 11 | | Pen sticking from 0915-1010, and 1650-1820 |
| | 12 | | Pen stuck from 1100-1450 |
| | 14 | | Pen stuck from 1045-1130 |
| | 20 | | Pen stuck from 1315-1520 |
| | 21 | | Pen stuck from 1130-1205 |
| | 22 | | Pen stuck from 1020-1210 and 1220-1230 |
| | 24 | | Pen stuck from 1100-1200 |
| | 26 | No data from 0820-1530 | |
| May | | No Faults | |
| June | 30 | Missing | |
| | 29 | Bad data from 0845 on | |

Station: Atlanta
Year: 1956

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| January | | No Faults | |
| February | 25 | | No reading from 0910-1540 |
| | 27 | No data after 1000 | |
| | 28 | No data | Recorder inoperative |
| | 29 | No data | Recorder inoperative |
| March | 20 | | Data bearly legible from 1100-1200 |
| April | | No Faults | |
| May | 15 | | Ink pen skipping from 1140-1500 |
| June | 6 | No data | |
| | 7 | No data till 0845 | |
| | 11-30 | No data | |
| July | | No data | |
| August | | No data | |
| September | | No data | |
| October | | No data until 22, at 1420 | |
| November | 3-5 | No data | |
| December | 10 | No data | |

Station: Atlanta
Year: 1957

| Month | Day | Data Fault | Comment |
|---|---|---|---|
| January | 16 | No data from 0830-1330 | |
| | 22 | No data from 1030-1300 | |
| | 27 | | Very erratic |
| | 28 | | Note says counter erratic |
| | 29-31 | | Counter erratic, however solar data looks good |
| February | 4 | No data until 1300 | |
| | 19 | No data until 1145-on | |
| March | | No Faults | |
| April | | No Faults | |
| May | | No Faults | |
| June | | No Faults | |
| July | 2 | | No data after 1700 due to ink smear |
| | 3 | Legible data only between 1515-1900 | |
| | 29 | | Illegible from 1615-1730 due to ink smear |
| August | | No Faults | |
| September | 10 | | Pen stuck from 1010-1145 |
| October | 16 | No data after 1315 | |
| | 17 | No data | |
| | 24 | No data after 0845 | |
| November | | No Faults | |
| December | 8 | | Data illegible from 1015-1045 due to ink smear |

# APPENDIX II

Pyranometer History for Atlanta

(Obtained from E. Flowers)

| DATE | PROBLEM | FLAT CORR. FACTOR | DATE | PROBLEM | LINEAR CORR. FACTOR |
|---|---|---|---|---|---|
| | | **ATLANTA, GA** | | | |
| | | Sensor #1832 (L) | | | |
| 3-5-49 - 4-7-53 | Smithsonian Scale | .98 | 3-5-49 - 7-8-54 | Recalibration | 1.0 to .934 |
| | Midscale Chart Setting | 1.014 | | | |
| 4-7-53 - 4-30-54 | Smithsonian Scale | .98 | | | |
| | Midscale Chart Setting | 1.019 | | | |
| 4-30-54 - 7-8-54 | Smithsonian Scale | .98 | | | |
| | | Sensor #1608 (L) | | | |
| 7-8-54 - 6-19-56 | Smithsonian Scale | .98 | 7-8-54 - 6-19-56 | Broken | |
| 6-19-56 - 10-22-56 | No data | | | | |
| | | Sensor #1796 (L) | | | |
| 10-22-56 - 10-16-57 | Smithsonian Scale | .98 | 10-22-56 - 3-6-60 | Broken | |
| 10-16-57 - 3-6-60 | None | | | | |
| | | Sensor #2271 (P) | | | |
| 3-19-60 - 11-21-61 | None Available | | 3-19-60 - 11-21-61 | Broken | |
| | | Sensor #655 (P) | | | |
| 11-28-61 - 2-8-65 | None Available | | 11-28-61 - 2-8-65 | Broken | |
| | | Sensor #2599 (P) | | | |
| 2-8-65 - 11-29-68 | Crossmatch | .930 | 2-8-65 - 11-29-68 | Recalibration | 1.0 to 1.072 |
| | | Sensor #3327 (P) | | | |
| 11-28-68 - 9-24-69 | None | | 11-29-68 - 9-24-69 | Broken | |
| | | Sensor #1803 (P) | | | |
| 9-24-69 - 1-30-70 | None | | 9-24-69 - 1-30-70 | Broken | |

| DATE | PROBLEM | FLAT CORR. FACTOR | DATE | PROBLEM | LINEAR CORR. FACTOR |
|---|---|---|---|---|---|
| | | ATLANTA, GA (Cont'd) | | | |
| | | Sensor #1610 (P) | | | |
| 1-30-70 - 4-24-73 | None | | 1-30-70 - 4-24-73 | Recalibration | 1.0 to 1.255 |
| | | Sensor #7544 (P) | | | |
| 4-24-73 - 6-28-73 | None | | 4-24-73 - 6-28-73 | None | |
| | | Sensor #10565F4 | | | |
| 6-28-73 - 7-3-73 | None | | 6-8-73 - 7-3-73 | Broken | |
| | | Sensor #11938F3 | | | |
| 7-3-73 - 7-25-74 | None | | 7-3-73 - 7-25-74 | Broken | |
| | | Sensor #9903F3 | | | |
| 7-25-74 - 11-5-74 | None | | 7-25-74 - 11-5-74 | Broken (Closed) | |

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
AEROSPACE ENGINEERING

DANIEL GUGGENHEIM SCHOOL
OF AERONAUTICS

404-894-3000

June 2, 1978

Mr. G. T. Kupper
Sandia Contracting Representative
Sandia Laboratories
Albuquerque, N.M. 87115

Subject: Contract 07-6958, Monthly Technical Report, May, 1978.

Dear Mr. Kupper:

Progress on the subject contract during May 1978 is summarized in this monthly letter technical report. The report is indexed by Tasks as defined in the Attachment to the March 1978 report.

Task 2.1 - Continuing. The data covering operation of the Met Station from 20, December, 1977 onward are being transcribed at EG & G and several months should be available for analysis during June. In addition to the radiation fields, we will also be evaluating the dry bulb temperatures.

Task 2.2, 2.3 - continuing

Task 1.8 - The Phase I report was delivered to R. Hunke on 3, May 1978. We are most interested in obtaining permission to use the Model Year data for other comparisons and studies here at Georgia Tech, and in addition, we have had several external requests for copies. We would like to obtain permission to release this data to interested users along with, of course, a suitable disclaimer releasing Georgia Tech and the Sponsor from any liability arising from the use of the data.

A meeting was held with R. Hunke at Albuquerque in early May to resolve questions about operation and data retrieval for the Met Station. Since there was some uncertainty as to the precise status of the new logger being constructed at EG & G, it was not possible to establish a firm schedule. Consequently, it has not been possible to prepare a revised Phase II work plan as noted in the April report. We will begin analyzing the new data from EG & G as mentioned under Task 2.1 above, but until we are able to work out details of future station operation, it will not be possible to prepare a detailed Phase II plan.

Sincerely,

J. I. Craig, Associate Professor
Aerospace Engineering

cc: J. R. Williams
S. Jeter

JIC/cj

Sandia Laboratories
PURCHASING ORGANIZATION

ALBUQUERQUE, NEW MEXICO 87115
LIVERMORE, CALIFORNIA 94550

# MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 5-31-78

| | | |
|---|---|---|
| TOTAL FUNDS AUTHORIZED | | $ 43,840.00 |
| ACTUAL COST INCURRED TO DATE(2) | | 25,564.45 |
| ESTIMATED COST TO COMPLETE:(3) | | |
| 1ST MONTH FOLLOWING (1) | 4,568.88 | |
| 2ND MONTH | 4,568.88 | |
| 3RD MONTH | 4,568.88 | |
| 4TH MONTH | 4,568.91 | |
| 5TH MONTH | | |
| 6TH MONTH | | |
| BALANCE OF FISCAL YEAR(4) | | |
| SUBSEQUENT FISCAL YEARS | | |
| TOTAL ESTIMATE TO COMPLETE | | 18,275.55 |
| TOTAL ESTIMATED COST AT COMPLETION | | $ 43,840.00 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE.

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

SF 6432-CS (3-76)

GEORGIA INSTITUTE OF TECHNOLOGY

ATLANTA, GEORGIA 30332

SCHOOL OF
MECHANICAL ENGINEERING

July 7, 1978

Mr. G. T. Kupper
Sandia Contracting Representative
Sandia Laboratories
Albuquerque, New Mexico 87115

Subject: Contract 07-6958, Monthly Technical Report, June 1978.

Dear Mr. Kupper:

Progress on the subject contract during June 1978 is summarized in this monthly letter technical report. The report is indexed by Tasks as defined in the Attachment to the March 1978 report.

Task 1.9 -The model year tapes, version 2 and version 12, have been found to contain inconsistent dew point and dry bulb temperatures. This has resulted in excessive latent heat loads when the data are used for building load calculations. After considerable checking, the problem was traced to a coding problem with the TDF-1440 tape from which the standard surface observations were obtained.All data values which were even multiples of 10 were increased by 10. The radiation data were not affected. The data are currently being corrected and a new tape, version 14, will be issued during the last week in June.

Task 2.1 -The September-December station data have been analyzed, but since the model year data (above) were found to be in error, the comparison will be reworked during July. The following table compares the global radiation data only (units=Langley per day):

| | Station Data | | Model Year | | Atlanta 1964 | | Atlanta TRY | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Std.Dev. | Mean | Std.Dev. | Mean | Std.Dev. | Mean | Std.Dev. |
| Sept. | 329[1] | 112 | 424 | 140 | 432 | 110 | 455 | - |
| Oct. | 404[2] | 209 | 348 | 134 | 348 | 98 | 376 | - |
| Nov. | 196[3] | 98 | 276 | 135 | 245 | 89 | 286 | - |
| Dec. | 142[4] | 58 | 209 | 111 | 168 | 67 | 234 | - |

Notes: Number of acceptable daily records:
Criteria: > 25 15 min. average records per acceptable day (with less than 40% missing data and more than 90% acceptable data in each record)

1 17 days
2 19 days
3 14 days
4 5 days

Task 2.2-2.3 - Continuing.

Sincerely,

v. M. Becker

J. I. Craig
Associate Professor
Aerospace Engineering

# MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 6-30-78

| | | |
|---|---|---|
| TOTAL FUNDS AUTHORIZED | | $ 43,840.00 |
| ACTUAL COST INCURRED TO DATE (2) | | 28,663.42 |
| ESTIMATED COST TO COMPLETE: (3) | | |
| 1ST MONTH FOLLOWING (1) | 5,058.86 | |
| 2ND MONTH | 5,058.86 | |
| 3RD MONTH | 5,058.86 | |
| 4TH MONTH | | |
| 5TH MONTH | | |
| 6TH MONTH | | |
| BALANCE OF FISCAL YEAR (4) | | |
| SUBSEQUENT FISCAL YEARS | | |
| TOTAL ESTIMATE TO COMPLETE | | 15,176.58 |
| TOTAL ESTIMATED COST AT COMPLETION | | $ 43,840.00 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE.

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
AEROSPACE ENGINEERING

404-894-3000

DANIEL GUGGENHEIM SCHOOL
OF AERONAUTICS

August 10, 1978

Mr. G. T. Kupper
Sandia Contracting Representative
Sandia Laboratories
Albuquerque, New Mexico 87115

Subject: Contract 07-6958 Monthly Technical Report, July, 1978.

Dear Mr. Kupper:

Progress on the subject contract during July is summarized in this monthly letter technical report which is indexed by Tasks as defined in the March 1978 report.

Task 1.9 -Version 14 of the model year tape which corrects errors in the dew point and dry bulb temperatures was issued.

Task 2.1 -2.3 - awaiting date tapes from EG & G. Conversations with Jack Penuelas (EG & G) indicate that some data will be available in August.

Task 2.4 -The attached Figure 1 shows a comparison of the monthly average daily total global radiation for each month between various models and the preliminary Met Station data for Sept. - Dec. 1977. The models are as follows:

| | |
|---|---|
| Model Year - | Version 14 of the model developed on the present contract |
| TRY Year - | synthesized data from the Aerospace TRY tape for Atlanta as obtained from Sandia Labs. |
| 1964 Model Year - | synthesized data produced at Georgia Tech for use in the design studies for the Shenandoah Recreational Center. |

Note also that the $\pm$ one sigma limits for the current Model Year are shown and that they include all other models and the Met Station data. Generally, the models agree well with some difference most notable in June. The TRY model appears to be about 7% higher than the other models on an annual basis.

Figure 2 shows a comparison of temperatures. Again, the models are generally in good agreement except for two months in the winter. Overall, the TRY model appears to be about 3% higher than the others.

As a final note, in response to comments made at the Shenandoah STE-LSE Design Review #3 at the GE Valley Forge Space Center, July 18-19, we are now making the final editing of our preliminary report on the Model Year development and plan to issue it as a published report.

Sincerely,

J. I. Craig
Associate Professor

JIC/cj

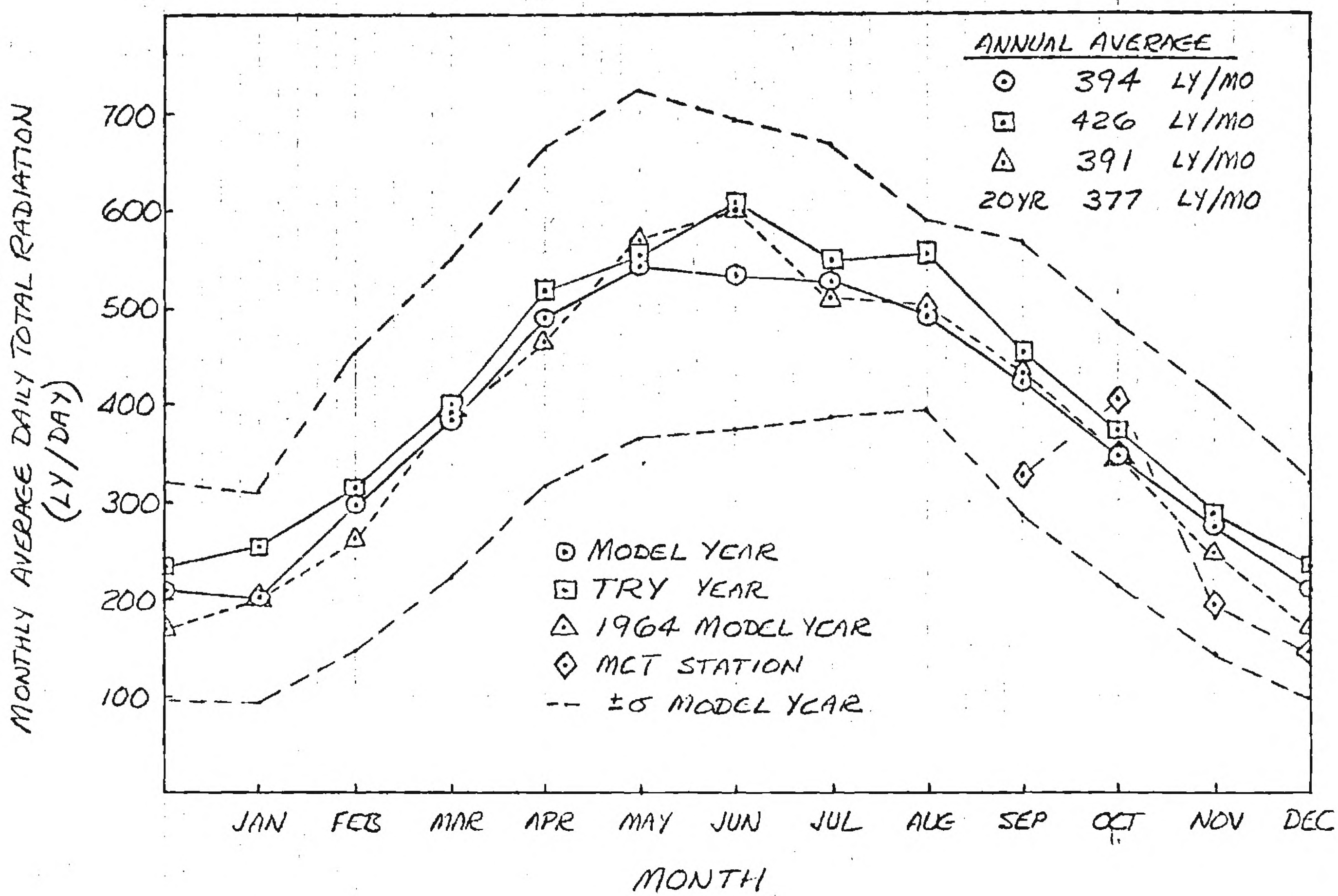



FIG 1. MODEL YEAR SOLAR CHARACTERISTICS

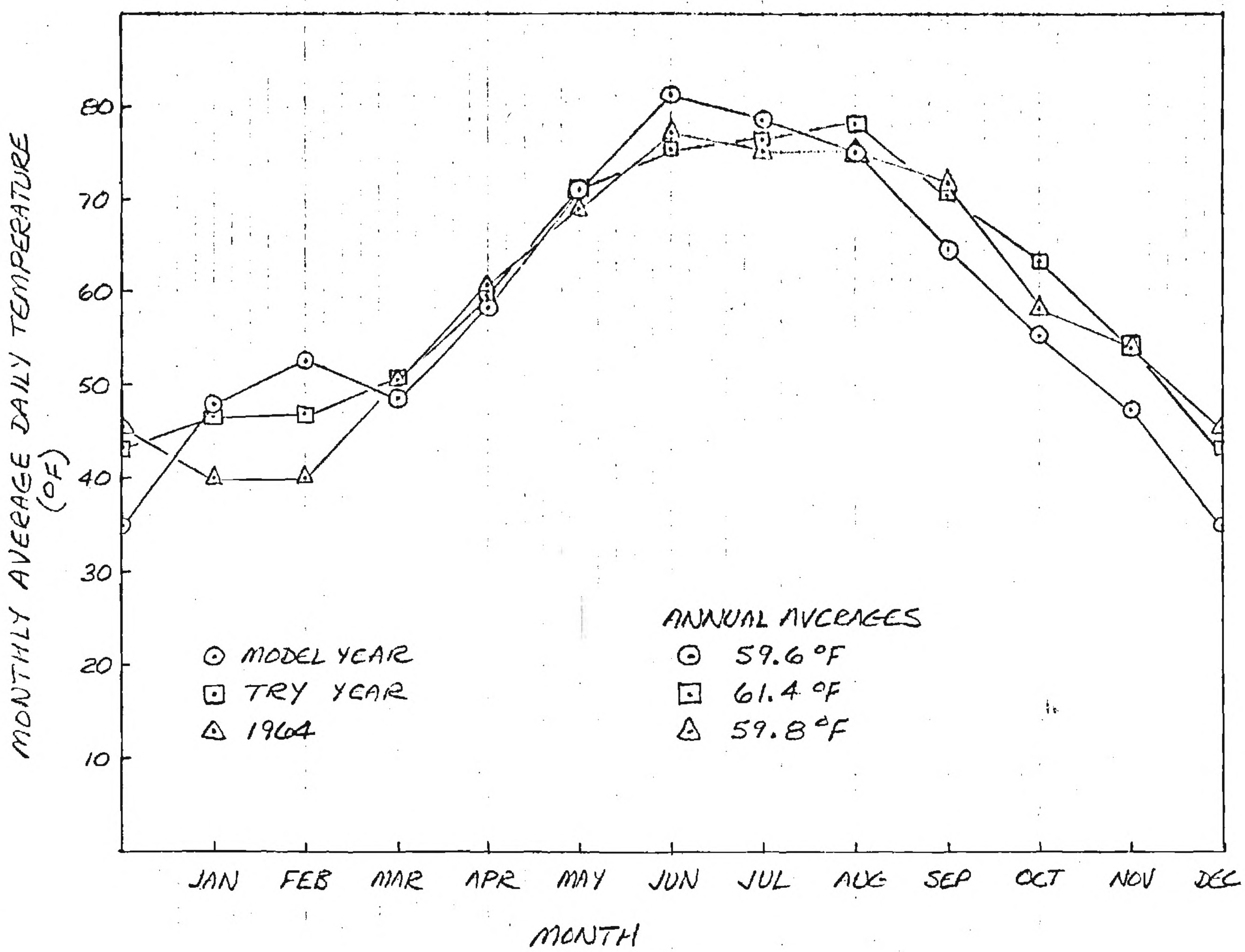



FIG 2. MODEL YEAR TEMPERATURE CHARACTERISTICS

**Sandia Laboratories**
PURCHASING ORGANIZATION

ALBUQUERQUE, NEW MEXICO
LIVERMORE, CALIFORNIA

# MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 7-31-78

| | | |
|---|---|---|
| TOTAL FUNDS AUTHORIZED | | $ 43,840.00 |
| ACTUAL COST INCURRED TO DATE (2) | | 29,969.55 |
| ESTIMATED COST TO COMPLETE: (3) | | |
| 1ST MONTH FOLLOWING (1) | 6,935.22 | |
| 2ND MONTH | 6,935.23 | |
| 3RD MONTH | | |
| 4TH MONTH | | |
| 5TH MONTH | | |
| 6TH MONTH | | |
| BALANCE OF FISCAL YEAR (4) | | |
| SUBSEQUENT FISCAL YEARS | | |
| TOTAL ESTIMATE TO COMPLETE | | 13,870.45 |
| TOTAL ESTIMATED COST AT COMPLETION | | $ 43,840.00 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE.

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
MECHANICAL ENGINEERING

September 15, 1978

Mr. G. T. Kupper
Sandia Contracting Representative
Sandia Laboratories
Albuquerque, New Mexico 87115

Subject: Contract 07-6958 Monthly Technical Report, August 1978.

Dear Mr. Kupper:

Progress on the subject contract during August is summarized in this monthly letter technical report which is indexed by Tasks as defined in the March 1978 report.

Task 1.9 - Version 18 of the model year tape was issued. This version includes some met data previously shown as missing and corrects a problem with wind direction. The solar portion is unchanged, however.

Tasks 2.1 - 2.4 - Awaiting tapes from EG & G. We have received a test tape from EG & G and were able to read it without problems. We expect a data tape for the first few months sometime in early September. Primary emphasis will be on getting the data processed as quickly as possible, and as a result, no attempts will be made at this time to reconstruct erratic, missing or out-of-sequence data from the first few months of station operation.

Sincerely,

J. I. Craig
Associate Professor
Aerospace Engineering

JIC/cs
enclosure

# MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 8-31-78

| | | |
|---|---|---|
| TOTAL FUNDS AUTHORIZED | | $ 43,840.00 |
| ACTUAL COST INCURRED TO DATE (2) | | 30,821.55 |
| ESTIMATED COST TO COMPLETE: (3) | | |
| 1ST MONTH FOLLOWING (1) | 13,018.45 | |
| 2ND MONTH | | |
| 3RD MONTH | | |
| 4TH MONTH | | |
| 5TH MONTH | | |
| 6TH MONTH | | |
| BALANCE OF FISCAL YEAR (4) | | |
| SUBSEQUENT FISCAL YEARS | | |
| TOTAL ESTIMATE TO COMPLETE | | 13,018.45 |
| TOTAL ESTIMATED COST AT COMPLETION | | $ 43,840.00 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE.

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

E15-609

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
MECHANICAL ENGINEERING

October 2, 1978

Mr. G. T. Kupper
Sandia Contracting Representative
Sandia Laboratories
Albuquerque, New Mexico 87115

Subject: Contract 07-6958 Monthly Technical Report, September 1978

Dear Mr. Kupper:

Progress on the subject contract during September is summarized in this monthly letter technical report which is indexed by Tasks as defined in the March 1978 report.

The additional funding on this project has been received, bringing the total authorization to $99,954.00. Presently the rate of expenditure lags the scheduled rate because the delay in receiving data tapes from EG&G has resulted in delaying the Phase 2 tasks.

<u>Task 2.1 - 2.4</u> - Still awaiting tapes from EG&G which will allow analysis, comparison and model development activities to begin.

Very truly yours,

Sheldon M. Jeter
Research Engineer

SMJ/cs
enclosures

RECEIVED
OCT 4 1978
OFFICE OF CONTRACT
ADMINISTRATION

Sandia Laboratories
PURCHASING ORGANIZATION

ALBUQUERQUE, NEW MEXICO
LIVERMORE, CALIFORNIA

# MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 9-30-78

| | |
|---|---|
| TOTAL FUNDS AUTHORIZED | $ 99,954.00 |
| ACTUAL COST INCURRED TO DATE (2) | 31,614.55 |
| ESTIMATED COST TO COMPLETE: (3) | |
| 1ST MONTH FOLLOWING (1) 4,271.00 | |
| 2ND MONTH 4,271.00 | |
| 3RD MONTH 4,271.00 | |
| 4TH MONTH 4,271.00 | |
| 5TH MONTH 4,271.00 | |
| 6TH MONTH 4,271.00 | |
| BALANCE OF FISCAL YEAR (4) 25,627.00 | |
| SUBSEQUENT FISCAL YEARS 17,086.45 | |
| TOTAL ESTIMATE TO COMPLETE | 68,339.45 |
| TOTAL ESTIMATED COST AT COMPLETION | $ 99,954.00 |

NOTES:

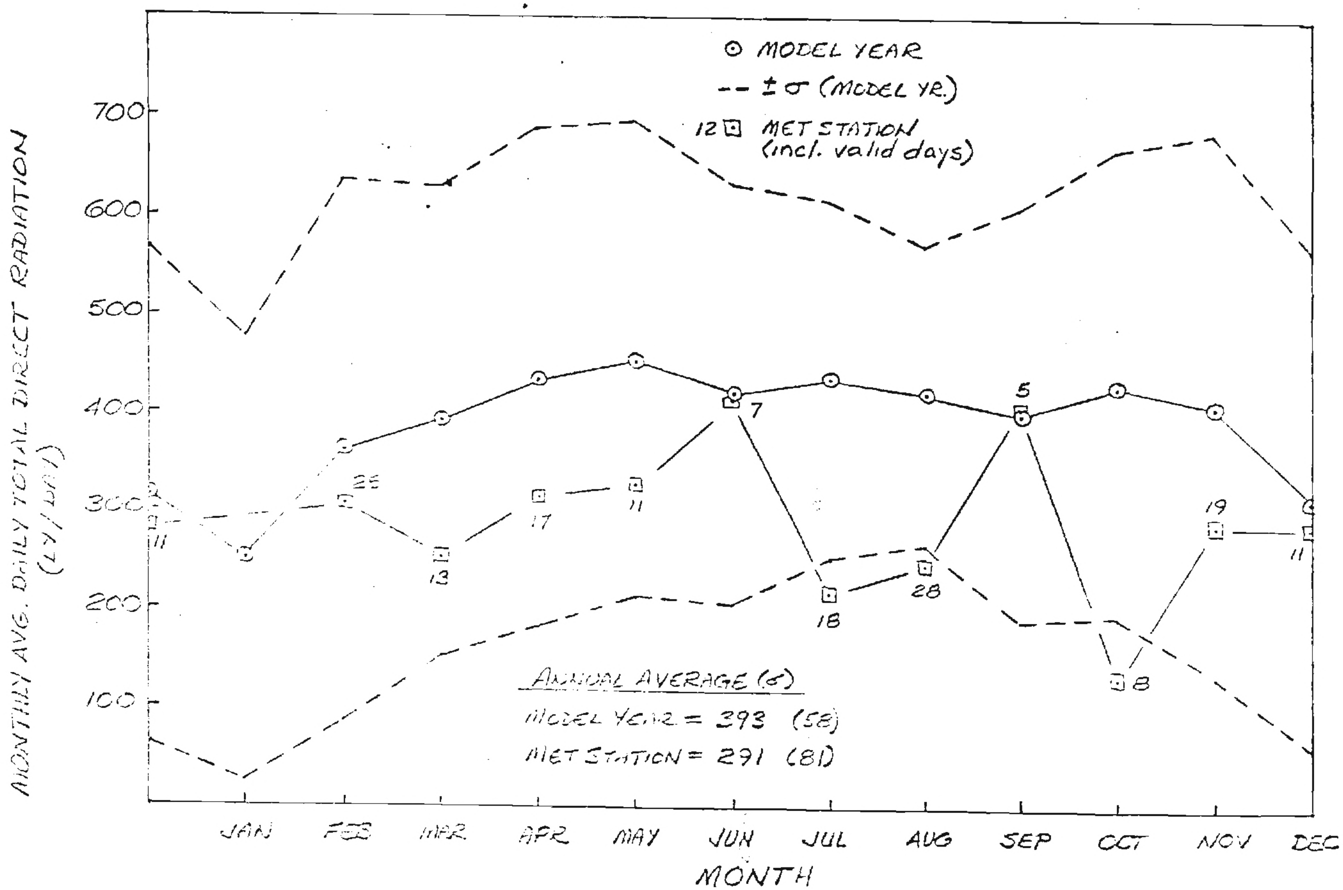
(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE.

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

SF 6432-CS (3-76)




[illegible] OF MET STATION DIRECT NORMAL RADIATION
[illegible] YEAR – NOVEMBER 1978

Sandia Laboratories
PURCHASING ORGANIZATION

ALBUQUERQUE, NEW MEXICO 87115
LIVERMORE, CALIFORNIA 94550

# MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 10-31-78

| | | |
|---|---|---|
| TOTAL FUNDS AUTHORIZED | | $ 99,954.00 |
| ACTUAL COST INCURRED TO DATE (2) | | 32,976.66 |
| ESTIMATED COST TO COMPLETE: (3) | | |
| 1ST MONTH FOLLOWING (1) | 5,125.20 | |
| 2ND MONTH | 5,125.20 | |
| 3RD MONTH | 5,125.20 | |
| 4TH MONTH | 5,125.20 | |
| 5TH MONTH | 5,125.20 | |
| 6TH MONTH | | |
| BALANCE OF FISCAL YEAR (4) | 24,264.89 | |
| SUBSEQUENT FISCAL YEARS | 17,086.45 | |
| TOTAL ESTIMATE TO COMPLETE | | 66,977.34 |
| TOTAL ESTIMATED COST AT COMPLETION | | $ 99,954.00 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE.

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

Sandia Laboratories
PURCHASING ORGANIZATION

ALBUQUERQUE, NEW MEXICO 87115
LIVERMORE, CALIFORNIA 94550

# MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 10-31-78

| | | |
|---|---|---|
| TOTAL FUNDS AUTHORIZED | | $ 99,954.00 |
| ACTUAL COST INCURRED TO DATE (2) | | 32,976.66 |
| ESTIMATED COST TO COMPLETE: (3) | | |
| 1ST MONTH FOLLOWING (1) | 5,125.20 | |
| 2ND MONTH | 5,125.20 | |
| 3RD MONTH | 5,125.20 | |
| 4TH MONTH | 5,125.20 | |
| 5TH MONTH | 5,125.20 | |
| 6TH MONTH | | |
| BALANCE OF FISCAL YEAR (4) | 24,264.89 | |
| SUBSEQUENT FISCAL YEARS | 17,086.45 | |
| TOTAL ESTIMATE TO COMPLETE | | 66,977.34 |
| TOTAL ESTIMATED COST AT COMPLETION | | $ 99,954.00 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE.

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

SF 6432-CS (3-76)

**Sandia Laboratories**
PURCHASING ORGANIZATION

ALBUQUERQUE, NEW MEXICO 87115
LIVERMORE, CALIFORNIA 94550

# MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 10-31-78

| | | |
|---|---|---|
| TOTAL FUNDS AUTHORIZED | | $ 99,954.00 |
| ACTUAL COST INCURRED TO DATE (2) | | 32,976.66 |
| ESTIMATED COST TO COMPLETE: (3) | | |
| 1ST MONTH FOLLOWING (1) | 4,271.00 | |
| 2ND MONTH | 4,271.00 | |
| 3RD MONTH | 4,271.00 | |
| 4TH MONTH | 4,271.00 | |
| 5TH MONTH | 4,271.00 | |
| 6TH MONTH | 4,271.00 | |
| BALANCE OF FISCAL YEAR (4) | 24,264.89 | |
| SUBSEQUENT FISCAL YEARS | 17,086.45 | |
| TOTAL ESTIMATE TO COMPLETE | | 66,977.34 |
| TOTAL ESTIMATED COST AT COMPLETION | | $ 99,954.00 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE.

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

SF 6432-CS (3-76)

Sandia Laboratories
PURCHASING ORGANIZATION

ALBUQUERQUE, NEW MEXICO 87115
LIVERMORE, CALIFORNIA 94550

# MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 11-30-78

| | | |
|---|---|---|
| TOTAL FUNDS AUTHORIZED | | $ 99,954.00 |
| ACTUAL COST INCURRED TO DATE (2) | | 35,613.87 |
| ESTIMATED COST TO COMPLETE: (3) | | |
| 1ST MONTH FOLLOWING (1) | 4.271.00 | |
| 2ND MONTH | 4,271.00 | |
| 3RD MONTH | 4,271.00 | |
| 4TH MONTH | 4,271.00 | |
| 5TH MONTH | 4,271.00 | |
| 6TH MONTH | 4,271.00 | |
| BALANCE OF FISCAL YEAR (4) | 21,627.68 | |
| SUBSEQUENT FISCAL YEARS | 17,086.45 | |
| TOTAL ESTIMATE TO COMPLETE | | 64,340.13 |
| TOTAL ESTIMATED COST AT COMPLETION | | $ 99,954.00 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE.

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

SF 6432-CS (3-76)

E-15-60

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
AEROSPACE ENGINEERING

DANIEL GUGGENHEIM SCHOOL
OF AERONAUTICS

404-894-3000

December 6, 1978

Mr. G. T. Kupper
Sandia Contracting Representative
Sandia Laboratories
Albuquerque, New Mexico 87115

Subject: Contract 07-6958 Monthly Technical Report, November 1978

Dear Mr. Kupper:

Progress on the subject contract during November is summarized in this monthly letter technical report.

Task 2.1 - The first 40% of the first year of Met Station data has been transcribed into SOLMET format. Copies of the data without missing data filled in were delivered to Sandia and GE. The remaining data is expected from EG&G within the next 6 weeks.

Task 2.2 - Underway.
Task 2.3 - Underway when balance of year 1 data arrives.
Task 2.4 - Underway.
Task 2.5 - Underway.

Recently, major changes in the Met Station layout and operation were made. Since this will have some affect on the present work, the alterations are summarized below.

During 8-11 November, a new and substantially improved model of the data logger was installed by EG&G and Georgia Tech personnel. No problems were encountered in the changeover and the new system was functioning on 10 November. Key features of the new logger are:

1. Channel capacity expanded from 8 to 16 channels.
2. All signals are sampled at 2 sec. intervals and are digitally integrated over the specified measurement period.
3. The display is capable of indicating transducer outputs in engineering units using previously stored calibration values.
4. The tape cassette is buffered so that no data is lost during routine tape changes.
5. The logger is capable of operation for up to 24 hours without external power. After this point, only the processor and clock are maintained by internal batteries.
6. Tapes can be read directly on TI 733 ASR terminals.

The new system has been in operation without problems and the tapes which are changed at weekly intervals are being processed here on the campus.

At the same time as the logger upgrade was made, Georgia Tech added 7 additional solar instruments to the Station (an 8th instrument will be employed for short-term studies). These additions extend the measurement capability to the UV and IR wavelengths. Also included are direct measurement of diffuse radiation, measurement of rainfall, and measurement of atmospheric scattering. This extended data will be reported along with the basic 8 Sandia/EG&G channels.

Sincerely,

J. I. Craig
Associate Professor

JIC/cs
attachment

Sandia Laboratories
PURCHASING ORGANIZATION

ALBUQUERQUE, NEW MEXICO 87115
LIVERMORE, CALIFORNIA 94550

# MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 11-30-78

| | | |
|---|---|---|
| TOTAL FUNDS AUTHORIZED | | $ 99,954.00 |
| ACTUAL COST INCURRED TO DATE (2) | | 35,613.87 |
| ESTIMATED COST TO COMPLETE: (3) | | |
| 1ST MONTH FOLLOWING (1) | 6,406.50 | |
| 2ND MONTH | 6,406.50 | |
| 3RD MONTH | 6,406.50 | |
| 4TH MONTH | 6,406.50 | |
| 5TH MONTH | | |
| 6TH MONTH | | |
| BALANCE OF FISCAL YEAR (4) | 21,627.68 | |
| SUBSEQUENT FISCAL YEARS | 17,086.45 | |
| TOTAL ESTIMATE TO COMPLETE | | 64,340.13 |
| TOTAL ESTIMATED COST AT COMPLETION | | $ 99,954.00 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE.

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

SF 6432-CS (3-76)

E-15-609

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF AEROSPACE ENGINEERING

DANIEL GUGGENHEIM SCHOOL OF AERONAUTICS

404-894-3000

November 14, 1978

Mr. G. T. Kupper
Sandia Contracting Representative
Sandia Laboratories
Albuquerque, New Mexico 87115

Subject: Contract 07-6958 Monthly Technical Report, October 1978

Dear Mr. Kupper:

Progress on the subject contract during October is summarized in this monthly letter technical report.

Task 2.1 - Transcribed 9 track data tapes were received from EG&G in mid-September and mid-October. Approximately 40% of the first year's data (covering October 1977-September 1978) were included on these two tapes. This is the first receipt of Met Station data.

Task 2.2 - The above data have been evaluated and the most recent instrument calibrations were used to normalize the radiation readings. (EG&G uses a nominal calibration value for each instrument while our correction takes into account the most recent Sandia Labs calibration.)

Task 2.3 - Since only 40% of the data is available now but a majority of the rest is expected shortly, no attempt has been made to fill in missing data.

Task 2.4 - Under way.

Task 2.5 - The attached figure shows a preliminary comparison of the data from Task 2.1 compared to the Solar Model Year. Each point for the Met Station represents the average of the daily direct radiation totals for all data currently available for that month. The small figure next to the symbol lists the number of days used. Days for which less than 50% of the data were missing were not included. Clearly, the comparison while generally within $\pm 1\ \sigma$, is difficult to make at this point due to the relatively small amount of data now available. The two months, July and August, for which a large amount of data are available do, however, tend to be significantly lower than the model year. The summary at the bottom of the figure lists the annual averages and standard deviations for comparison.

The preliminary results described above will be presented at the GE design review in Washington, November 15.

Sincerely,

J. I. Craig
Associate Professor

JIC/cs
attachments

Sandia Laboratories
PURCHASING ORGANIZATION

ALBUQUERQUE, NEW MEXICO 8711
LIVERMORE, CALIFORNIA 9455

# MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 11-30-78

| | | |
|---|---|---|
| TOTAL FUNDS AUTHORIZED | | $ 99,954.00 |
| ACTUAL COST INCURRED TO DATE(2) | | 35,613.87 |
| ESTIMATED COST TO COMPLETE:(3) | | |
| 1ST MONTH FOLLOWING (1) | 4.271.00 | |
| 2ND MONTH | 4,271.00 | |
| 3RD MONTH | 4,271.00 | |
| 4TH MONTH | 4,271.00 | |
| 5TH MONTH | 4,271.00 | |
| 6TH MONTH | 4,271.00 | |
| BALANCE OF FISCAL YEAR(4) | 21,627.68 | |
| SUBSEQUENT FISCAL YEARS | 17,086.45 | |
| TOTAL ESTIMATE TO COMPLETE | | 64,340.13 |
| TOTAL ESTIMATED COST AT COMPLETION | | $ 99,954.00 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE.

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

SF 6432-CS (3-76)

SRP

Sandia Laboratories
PURCHASING ORGANIZATION

ALBUQUERQUE, NEW MEXICO 87115
LIVERMORE, CALIFORNIA 94550

# MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 11-30-78

| | | |
|---|---|---|
| TOTAL FUNDS AUTHORIZED | | $ 99,954.00 |
| ACTUAL COST INCURRED TO DATE (2) | | 35,613.87 |
| ESTIMATED COST TO COMPLETE: (3) | | |
| 1ST MONTH FOLLOWING (1) | 4.271.00 | |
| 2ND MONTH | 4,271.00 | |
| 3RD MONTH | 4,271.00 | |
| 4TH MONTH | 4,271.00 | |
| 5TH MONTH | 4,271.00 | |
| 6TH MONTH | 4,271.00 | |
| BALANCE OF FISCAL YEAR (4) | 21,627.68 | |
| SUBSEQUENT FISCAL YEARS | 17,086.45 | |
| TOTAL ESTIMATE TO COMPLETE | | 64,340.13 |
| TOTAL ESTIMATED COST AT COMPLETION | | $ 99,954.00 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE.

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

E 15-609

# GEORGIA INSTITUTE OF TECHNOLOGY

ATLANTA, GEORGIA 30332

SCHOOL OF AEROSPACE ENGINEERING

404-894-3000

DANIEL GUGGENHEIM SCHOOL OF AERONAUTICS

January 10, 1979

Mr. G. T. Kupper
Sandia Contracting Representative
Sandia Laboratories
Albuquerque, New Mexico 87115

Subject: Contract 07-6958 Monthly Technical Report, December 1978

Dear Mr. Kupper:

Progress on the subject contract during December is summarized in this monthly letter technical report.

Task 2.1-2.3 - No new data has been received from EG&G.

Task 2.4 - Underway.

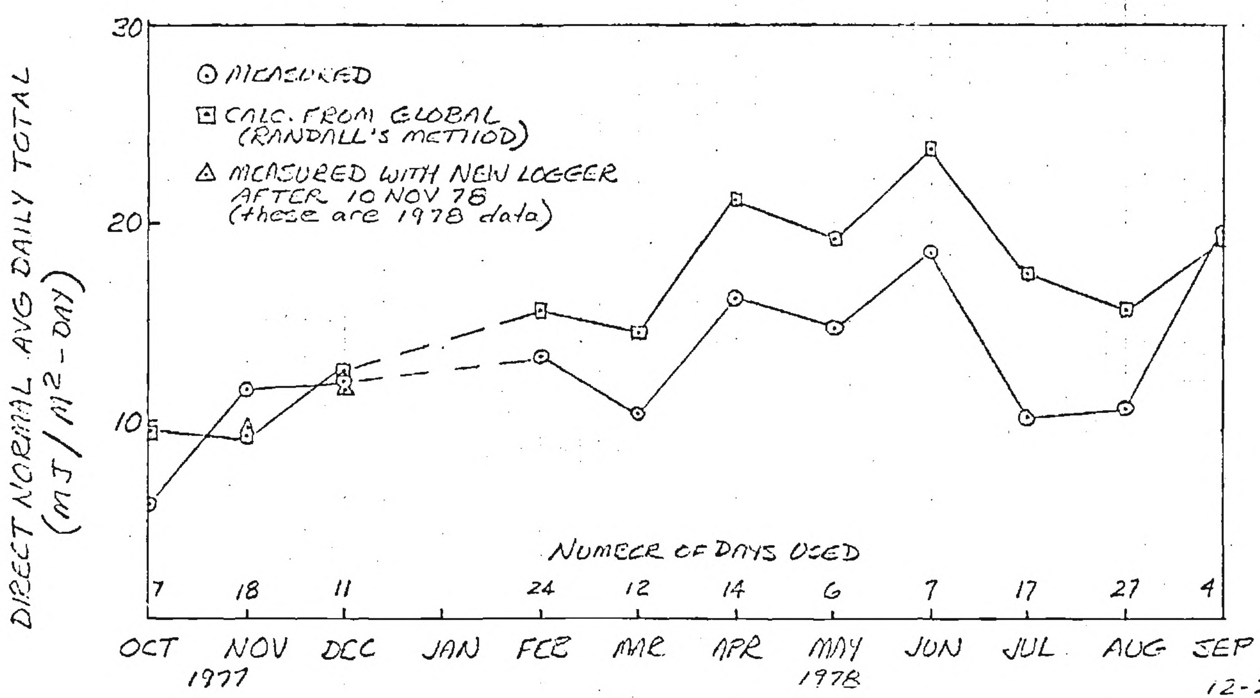
Task 2.5 - Continuing analysis of the data now in hand (approximately 40% of the past year) has revealed what appears to be lower than expected direct normal radiation values. This was apparent to some extent in the figure included in the November 1978 report. The measured direct normal has been compared with the calculated value as obtained using Randall's model and is shown in the attached figure. There appears to be a significant difference, especially during the past summer. It appears that this may be due in part at least to tracker alignment problems since the model is based entirely on global data. The alignment is normally checked at each site visit and adjusted if necessary. The basic drive alignment (latitude, NS) is not adjusted from the initial setting. Extended site visits have been undertaken and the NS and latitude alignments "fine tuned" at sunrise/sunset and solar noon. Data for November-December 1978 obtained by a new logger and processed at Georgia Tech directly are also shown on the attached figure. Satisfactory agreement is obtained over this period.

The new data logger has been working well, and we have now completed the transcription of data for November-December 1978. We anticipate no problems. We are, however, unable to continue with Tasks 2.1-2.3 without the balance of the data from EG&G. We have been told by them that it should be available "shortly" but at this point do not know how realistic this may be.

Sincerely,

J. I. Craig
Associate Professor

JIC/cs
attachments




12-20-78

COMPARISON OF MEASURED DIRECT NORMAL RADIATION WITH THAT PREDICTED FROM GLOBAL USING RANDALL'S METHOD

Sandia Laboratories
PURCHASING ORGANIZATION

ALBUQUERQUE, NEW MEXICO 87115
LIVERMORE, CALIFORNIA 94550

# MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 12-31-78

| | | |
|---|---|---|
| TOTAL FUNDS AUTHORIZED | | $ 99,954.00 |
| ACTUAL COST INCURRED TO DATE(2) | | $37,639.83 |
| ESTIMATED COST TO COMPLETE:(3) | | |
| 1ST MONTH FOLLOWING (1) | 4,271.00 | |
| 2ND MONTH | 4,271.00 | |
| 3RD MONTH | 4,271.00 | |
| 4TH MONTH | 4,271.00 | |
| 5TH MONTH | 4,271.00 | |
| 6TH MONTH | 4,271.00 | |
| BALANCE OF FISCAL YEAR(4) | 19,601.72 | |
| SUBSEQUENT FISCAL YEARS | 17,086.45 | |
| TOTAL ESTIMATE TO COMPLETE | | 62,314.17 |
| TOTAL ESTIMATED COST AT COMPLETION | | $ 99,954.00 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE.

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

SF 6432-CS (3-76)

GEORGIA INSTITUTE OF TECHNOLOGY

ATLANTA, GEORGIA 30332

SCHOOL OF
AEROSPACE ENGINEERING

404-894-3000

DANIEL GUGGENHEIM SCHOOL
OF AERONAUTICS

February 14, 1979

Mr. G. T. Kupper
Sandia Contracting Representative
Sandia Laboratories
Albuquerque, New Mexico 87115

Subject: Contract 07-6958 Monthly Technical Report, January 1979

Dear Mr. Kupper:

Progress on the subject contract during January is summarized in this monthly letter technical report.

Task 2.1.2.3 - A new data tape containing almost 75 percent of the cassette data recorded with the old logger from September 1977 to December 1978 was received during the first week of February. Analysis is now underway. Meanwhile, the new data logger has been working without problems and all data up to the current week have been transcribed. Preliminary analysis results are discussed below.

Task 2.4 - Underway.

Task 2.5 - Data from the new logger are summarized in the attached tables. Since its installation, only one week (one cassette) of data has been lost and this was due to operator error (which was corrected with a new operating manual). In order to test the accuracy of the global-direct normal decomposition method (Randall) used to construct the model year, it was applied to the new measured global insolation. The results are attached. The calculated 15 minute direct normal solar flux (DNSF) values are given along with the observed values. Also shown are the percent of sunshine as calculated from the DNSF by means of a Foster sunshine switch model. The overall results indicate good agreement between the observed and calculated DNSF values when averaged over each month. While the monthly average calculated DNSF values appear to bracket the observed values, the standard deviations are consistently smaller. This suggests that the calculated values lock the variability of the real data. The behavior is being explored further.

Sincerely,

J. I. Craig
Associate Professor

cs

Attachments

Sandia Laboratories
PURCHASING ORGANIZATION

ALBUQUERQUE, NEW MEXICO 87115
LIVERMORE, CALIFORNIA 94550

# MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 1-31-79

| | | |
|---|---|---|
| TOTAL FUNDS AUTHORIZED | | $ 99,954.00 |
| ACTUAL COST INCURRED TO DATE (2) | | 43,779.32 |
| ESTIMATED COST TO COMPLETE: (3) | | |
| 1ST MONTH FOLLOWING (1) | 4,271.00 | |
| 2ND MONTH | 4,271.00 | |
| 3RD MONTH | 4,271.00 | |
| 4TH MONTH | 4,271.00 | |
| 5TH MONTH | 4,271.00 | |
| 6TH MONTH | 4,271.00 | |
| BALANCE OF FISCAL YEAR (4) | 13,462.23 | |
| SUBSEQUENT FISCAL YEARS | 17,086.45 | |
| TOTAL ESTIMATE TO COMPLETE | | 56,174.68 |
| TOTAL ESTIMATED COST AT COMPLETION | | $ 99,954.00 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE.

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

SHENANDOAH MET STATION DAILY TOTALS

| DY | PD | WD | WS | RH | T(C) | KPA | DIR-1 | DIR-2 | SF-DIR | GLOBE | DIFUS | TILT | SP-GLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 38 | 194. | .2 | 124. | 8.1 | 99.1 | 7674. | 7375. | 6129. | 2714. | 129. | 5329. | 1647. |
| 7 | 96 | 88. | 1.4 | 136. | 11.8 | 99.2 | 1487. | 671. | 1040. | 5088. | 4538. | 5657. | 2655. |
| 8 | 96 | 158. | 2.0 | 142. | 18.6 | 98.8 | 468. | 438. | 356. | 3529. | 3070. | 3542. | 1744. |
| 9 | 96 | 241. | 3.3 | 140. | 7.5 | 98.3 | -170. | -607. | -919. | 1004. | 1193. | 962. | 274. |
| 10 | 96 | 237. | 1.1 | 123. | -2.8 | 99.7 | 29017. | 27499. | 26596. | 12370. | 1231. | 22221. | 7699. |
| 11 | 96 | 121. | .5 | 130. | -1.0 | 99.9 | 3689. | 2837. | 2284. | 6562. | 5255. | 9046. | 3617. |
| 12 | 96 | 184. | .6 | 124. | 1.8 | 99.9 | 28003. | 26593. | 25899. | 12148. | 1123. | 21857. | 7299. |
| 13 | 96 | 252. | .8 | 118. | 4.2 | 99.7 | 27598. | 26372. | 25610. | 12489. | 1417. | 21598. | 7417. |
| 14 | 96 | 202. | 1.2 | 115. | 2.1 | 99.6 | 18777. | 17806. | 17210. | 10879. | 3265. | 18716. | 6476. |
| 15 | 96 | 183. | .5 | 123. | 2.0 | 99.3 | 26995. | 25514. | 10028. | 12704. | 1702. | 21315. | 7540. |
| 16 | 96 | 190. | .5 | 142. | 8.8 | 99.1 | 32. | -411. | -4461. | 2809. | 2793. | 2659. | 1325. |
| 17 | 96 | 238. | 1.6 | 113. | 4.8 | 99.8 | 28937. | 27859. | -2383. | 12331. | 1011. | 22265. | 7477. |
| 18 | 96 | 217. | .7 | 120. | 3.1 | 99.4 | 1297. | 626. | 1880. | 6065. | 5678. | 6822. | 3315. |
| 19 | 96 | 208. | 1.8 | 141. | 14.3 | 98.5 | 25. | -186. | -1863. | 4725. | 4462. | 4655. | 2449. |
| 20 | 96 | 207. | 2.7 | 138. | 18.1 | 98.0 | 11894. | 11614. | -2141. | 9462. | 3449. | 14455. | 5337. |
| 21 | 96 | 259. | 1.6 | 131. | 9.5 | 98.0 | 20220. | 19576. | 88171. | 11094. | 2249. | 18777. | 6636. |
| 22 | 96 | 239. | .5 | 129. | 2.3 | 98.8 | 27718. | 25923. | 41732. | 12339. | 1254. | 21570. | 7195. |
| 23 | 96 | 183. | .7 | 124. | 4.1 | 98.7 | 12587. | 11579. | 57880. | 9739. | 4379. | 14714. | 5678. |
| 24 | 96 | 149. | 1.5 | 141. | 6.1 | 97.5 | -107. | -653. | 12859. | 1271. | 1493. | 1153. | 409. |
| 25 | 96 | 256. | .9 | 131. | 3.8 | 98.5 | 26016. | 24931. | -5435. | 11644. | 1509. | 20970. | 6918. |
| 26 | 96 | 260. | .5 | 120. | 4.7 | 99.0 | 27579. | 26241. | -3742. | 12162. | 1122. | 21313. | 7207. |
| 27 | 96 | 133. | 1.0 | 117. | 1.3 | 99.4 | 6717. | 5921. | 21290. | 8538. | 5543. | 11917. | 4984. |
| 28 | 96 | 89. | 1.9 | 107. | 1.7 | 99.5 | 12018. | 11123. | 4550. | 9814. | 4062. | 15321. | 5643. |
| 29 | 96 | 76. | 2.6 | 101. | 2.8 | 99.7 | 3328. | 2539. | 3901. | 6643. | 5837. | 8198. | 3680. |
| 30 | 96 | 81. | 2.2 | 142. | 2.8 | 99.7 | -96. | -791. | 35440. | 1857. | 2144. | 1706. | 714. |
| 31 | 96 | 107. | 1.9 | 143. | 10.9 | 99.5 | 5329. | 4919. | 76608. | 7886. | 5462. | 10683. | 4391. |
| 1 | 1 | 130. | 1.8 | 143. | 13.5 | 99.2 | -2. | -4. | -5. | -3. | -3. | -2. | -4. |
| AVG: | | 181. | 1.3 | 128. | 6.1 | 99.1 | 12112. | 11308. | 16241. | 7699. | 2791. | 12127. | 4434. |
| SIG: | | 60. | .8 | 12. | 5.5 | .6 | 11711. | 11333. | 24868. | 4246. | 1831. | 8082. | 2650. |

SHENANDOAH MET STATION DAILY TOTALS

| DY | PD | WD | WS | RH | T(C) | KPA | DIR-1 | DIR-2 | SP-DIR | GLOBE | DIFUS | TILT | SP-GLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 57 | 216. | .0 | 90. | 15.2 | 99.5 | 11717. | 11452. | 11341. | 11017. | 6949. | 15186. | 6614. |
| 11 | 96 | 246. | .3 | 94. | 12.3 | 99.4 | 21631. | 20924. | 20971. | 13471. | 11536. | 19887. | 8105. |
| 12 | 96 | 151. | .3 | 86. | 13.8 | 99.3 | 16441. | 15941. | 15894. | 12411. | 10123. | 17650. | 7388. |
| 13 | 96 | 107. | .7 | 83. | 14.3 | 99.3 | 13202. | 12797. | 12655. | 11454. | 9258. | 15690. | 6695. |
| 14 | 96 | 90. | .9 | 90. | 16.9 | 99.3 | 924. | 1080. | 1378. | 6458. | 3386. | 6988. | 3568. |
| 15 | 96 | 132. | .5 | 106. | 16.1 | 99.2 | 1189. | 1041. | 1057. | 6195. | 5251. | 6827. | 3308. |
| 16 | 96 | 157. | .6 | 94. | 17.9 | 99.2 | 6217. | 6119. | 6089. | 9610. | 7772. | 12329. | 5530. |
| 17 | 96 | 179. | 1.4 | 112. | 19.8 | 98.9 | 771. | 845. | 665. | 3684. | 3516. | 3750. | 1834. |
| 18 | 96 | 273. | .5 | 95. | 17.0 | 99.2 | 19204. | 4066. | 18425. | 11943. | 6563. | 18242. | 7127. |
| 19 | 96 | 153. | .8 | 86. | 10.6 | 99.5 | 17297. | 16714. | 16482. | 11760. | 8826. | 17888. | 7129. |
| 20 | 96 | 64. | 1.7 | 80. | 10.9 | 99.8 | 10199. | 9617. | 9380. | 9872. | 6418. | 13849. | 5784. |
| 21 | 96 | 110. | .9 | 72. | 9.8 | 99.6 | 17775. | 17260. | 16885. | 11590. | 8243. | 17961. | 6976. |
| 22 | 96 | 113. | .7 | 84. | 10.8 | 99.3 | 2643. | 2327. | 2228. | 7717. | 6865. | 8868. | 4341. |
| 23 | 96 | 151. | 1.6 | 89. | 15.0 | 98.9 | 4904. | -153. | 4641. | 7346. | 6268. | 9536. | 4079. |
| 24 | 96 | 262. | 1.2 | 71. | 16.1 | 98.7 | 20725. | 20120. | 20258. | 11938. | 9763. | 19301. | 6977. |
| 25 | 96 | 234. | .9 | 53. | 8.8 | 98.9 | 23800. | 23089. | 22772. | 12028. | 10378. | 20144. | 7141. |
| 26 | 96 | 159. | 1.6 | 67. | 10.8 | 98.4 | 9764. | 9297. | 9121. | 9941. | 9281. | 14113. | 5780. |
| 27 | 96 | 165. | 1.7 | 117. | 15.4 | 98.2 | -149. | -311. | -386. | 1001. | 976. | 836. | 310. |
| 28 | 96 | 216. | 1.0 | 94. | 11.5 | 99.0 | 3867. | 3564. | 3460. | 8133. | 7165. | 10275. | 4605. |
| 29 | 49 | 61. | .9 | 95. | 7.8 | 99.0 | -124. | -303. | -372. | 260. | 352. | 246. | 7. |
| AVG: | | 162. | .9 | 88. | 13.5 | 99.1 | 10100. | 8774. | 9647. | 8891. | 6944. | 12478. | 5165. |
| SIG: | | 63. | .5 | 15. | 3.3 | .4 | 8196. | 8001. | 7932. | 3786. | 3034. | 6290. | 2368. |

MONTH : 11

| DAY | COUNT | CALC. DNSF (KJ/M/M) | OBS. DNSF (KJ/M/M) | GLOBE (KJ/M/M) | AVE. PRESS (KPA) | AVE. TEMP. (D-C) | AVE. WSPD (M/S) | PCT SS |
|---|---|---|---|---|---|---|---|---|
| 315 | 96 | 19632. | 21690. | 13786. | 99.44 | 12.3 | .3 | 79.85 |
| 316 | 96 | 17871. | 16555. | 12683. | 99.34 | 13.8 | .3 | 89.75 |
| 317 | 96 | 14325. | 13333. | 11656. | 99.28 | 14.3 | .7 | 80.24 |
| 318 | 96 | 3134. | 1107. | 6546. | 99.30 | 16.9 | .9 | 17.06 |
| 319 | 96 | 2636. | 1396. | 6290. | 99.24 | 16.1 | .5 | 12.21 |
| 320 | 96 | 8744. | 6332. | 9677. | 99.16 | 17.9 | .6 | 63.66 |
| 321 | 96 | 1813. | 945. | 3710. | 98.93 | 19.8 | 1.4 | 12.27 |
| 322 | 96 | 16173. | 19315. | 12136. | 99.21 | 17.0 | .5 | 63.94 |
| 323 | 96 | 16370. | 17387. | 12043. | 99.50 | 10.6 | .8 | 78.87 |
| 324 | 96 | 10877. | 10310. | 10073. | 99.75 | 10.9 | 1.7 | 54.34 |
| 325 | 96 | 16602. | 17877. | 11858. | 99.55 | 9.8 | .9 | 89.09 |
| 326 | 96 | 5273. | 2810. | 7917. | 99.31 | 10.8 | .7 | 24.80 |
| 327 | 96 | 6983. | 5124. | 7449. | 98.93 | 15.0 | 1.6 | 44.72 |
| 328 | 96 | 18129. | 20871. | 12111. | 98.69 | 16.1 | 1.2 | 87.13 |
| 329 | 96 | 19187. | 23886. | 12330. | 98.94 | 8.8 | .9 | 92.28 |
| 330 | 96 | 12014. | 9858. | 10119. | 98.43 | 10.8 | 1.6 | 59.96 |
| 331 | 96 | 101. | 57. | 1043. | 98.17 | 15.4 | 1.7 | 0.00 |
| 332 | 96 | 7094. | 4055. | 8249. | 98.99 | 11.5 | 1.0 | 25.07 |

| DAYS | AVE. CALC. DNSF | DEV. | AVE. OBS. DNSF | DEV. | AVE. GLOBE | DEV. | AVE. PRESS | DEV. | AVE. TEMP | DEV. | AVE. WIND | DEV. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 10942. | 6611. | 10717. | 8240. | 9426. | 3430. | 99.1 | .4 | 13.8 | 3.2 | 1.0 | .5 |

MONTH : 1

| DAY | COUNT | CALC. DNSF (KJ/M/M) | OBS. DNSF (KJ/M/M) | GLOBE (KJ/M/M) | AVE. PRESS (KPA) | AVE. TEMP. (D-C) | AVE. WSPD (M/S) | PCT SS |
|---|---|---|---|---|---|---|---|---|
| 4 | 96 | 7574. | 5776. | 8471. | 100.79 | -4.1 | .4 | 27.90 |
| 5 | 96 | 5534. | 3686. | 7175. | 100.24 | 1.2 | .8 | 32.93 |
| 6 | 96 | 377. | 1. | 3197. | 99.40 | 5.9 | .8 | 0.00 |
| 7 | 96 | 106. | 0. | 1320. | 98.35 | 12.3 | 2.1 | 0.00 |
| 8 | 96 | 14581. | 17510. | 10101. | 99.10 | -1.1 | 2.0 | 58.04 |
| 9 | 96 | 23503. | 29473. | 13398. | 99.90 | -5.2 | .9 | 90.73 |
| 10 | 94 | 19955. | 22614. | 11727. | 99.84 | -1.1 | .6 | 88.08 |
| 11 | 96 | 19716. | 22806. | 12460. | 99.42 | 2.3 | .9 | 82.92 |
| 12 | 96 | 112. | 10. | 1430. | 98.61 | 2.6 | 2.8 | 0.00 |
| 13 | 96 | 149. | 0. | 2258. | 97.81 | 4.1 | 1.6 | 0.00 |
| 14 | 96 | 8398. | 8643. | 7942. | 98.68 | -.2 | 2.2 | 47.51 |
| 15 | 96 | 22866. | 26098. | 13554. | 100.00 | -3.0 | .6 | 92.36 |
| 16 | 96 | 9473. | 7550. | 9084. | 100.01 | .5 | .2 | 44.85 |
| 17 | 96 | 13023. | 11879. | 10485. | 99.63 | 7.4 | .7 | 57.20 |
| 18 | 96 | 15085. | 15372. | 11735. | 99.26 | 9.7 | 1.1 | 59.57 |
| 19 | 96 | 375. | 23. | 3727. | 99.04 | 3.3 | 2.4 | 0.00 |
| 20 | 96 | 77. | 0. | 1017. | 96.96 | 4.3 | 2.3 | 0.00 |
| 21 | 96 | 76. | 0. | 848. | 96.61 | 3.1 | 3.6 | 0.00 |
| 22 | 96 | 10163. | 8970. | 9261. | 98.42 | -.5 | 1.1 | 51.70 |
| 23 | 96 | 13786. | 12846. | 10653. | 97.91 | 3.0 | 2.0 | 58.96 |

| DAYS | AVE. CALC. DNSF | DEV. | AVE. OBS. DNSF | DEV. | AVE. GLOBE | DEV. | AVE. PRESS | DEV. | AVE. TEMP | DEV. | AVE. WIND | DEV. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 9246. | 8284. | 9663. | 9793. | 7492. | 4506. | 99.0 | 1.1 | 2.2 | 4.4 | 1.4 | .9 |

MONTH : 12

| DAY | COUNT | CALC. DNSF (KJ/M/M) | OBS. DNSF (KJ/M/M) | GLOBE (KJ/M/M) | AVE. PRESS (KPA) | AVE. TEMP. (D-C) | AVE. WSPD (M/S) | PCT SS |
|---|---|---|---|---|---|---|---|---|
| 341 | 96 | 2583. | 1656. | 5245. | 99.21 | 11.8 | 1.4 | 20.30 |
| 342 | 96 | 1628. | 690. | 3558. | 98.79 | 18.6 | 2.0 | 10.16 |
| 343 | 96 | 115. | 0. | 1180. | 98.29 | 7.5 | 3.3 | 0.00 |
| 344 | 96 | 23376. | 29040. | 12896. | 99.68 | -2.8 | 1.1 | 94.14 |
| 345 | 96 | 4497. | 3737. | 7009. | 99.89 | -1.0 | .5 | 28.01 |
| 346 | 96 | 23053. | 28052. | 12614. | 99.87 | 1.8 | .6 | 94.28 |
| 347 | 96 | 23669. | 27654. | 12905. | 99.67 | 4.2 | .8 | 94.34 |
| 348 | 96 | 17446. | 18847. | 11336. | 99.63 | 2.1 | 1.2 | 84.19 |
| 349 | 96 | 23741. | 27049. | 13126. | 99.33 | 2.0 | .5 | 94.44 |
| 350 | 96 | 577. | 185. | 2958. | 99.13 | 8.8 | .5 | 2.55 |
| 351 | 96 | 22426. | 29023. | 12727. | 99.83 | 4.8 | 1.6 | 91.95 |
| 352 | 96 | 3605. | 1366. | 6387. | 99.40 | 3.1 | .7 | 12.77 |
| 353 | 96 | 1431. | 204. | 4773. | 98.48 | 14.3 | 1.8 | 0.00 |
| 354 | 96 | 11970. | 12060. | 9512. | 97.98 | 18.1 | 2.7 | 56.22 |
| 355 | 96 | 17308. | 20342. | 11334. | 97.96 | 9.5 | 1.6 | 81.78 |
| 356 | 96 | 23262. | 27782. | 12814. | 98.79 | 2.3 | .5 | 92.00 |
| 357 | 96 | 13141. | 12651. | 10071. | 98.74 | 4.1 | .7 | 76.65 |
| 358 | 96 | 122. | 0. | 1470. | 97.51 | 6.1 | 1.5 | 0.00 |
| 359 | 96 | 20390. | 26089. | 12042. | 98.47 | 3.8 | .9 | 91.94 |
| 360 | 96 | 22598. | 27638. | 12575. | 98.96 | 4.7 | .5 | 91.91 |
| 361 | 96 | 9127. | 6797. | 8964. | 99.44 | 1.3 | 1.0 | 58.69 |
| 362 | 96 | 12601. | 12090. | 10160. | 99.50 | 1.7 | 1.9 | 61.21 |
| 363 | 96 | 4851. | 3408. | 6891. | 99.72 | 2.8 | 2.6 | 28.04 |
| 364 | 96 | 147. | 0. | 2071. | 99.72 | 2.8 | 2.2 | 0.00 |
| 365 | 96 | 6834. | 5426. | 8040. | 99.47 | 10.9 | 1.9 | 56.00 |

| DAYS | AVE. CALC. DNSF | DEV. | AVE. OBS. DNSF | DEV. | AVE. GLOBE | DEV. | AVE. PRESS | DEV. | AVE. TEMP | DEV. | AVE. WIND | DEV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 11620. | 9296. | 12871. | 11851. | 8506. | 4076. | 99.1 | .7 | 5.7 | 5.5 | 1.4 | [illegible] |

E-15-609

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
AEROSPACE ENGINEERING

404-894-3000

DANIEL GUGGENHEIM SCHOOL
OF AERONAUTICS

March 19, 1979

Mr. G. T. Kupper
Sandia Contracting Representative
Sandia Laboratories
Albuquerque, New Mexico 87115

Subject: Contract 07-6958 Monthly Technical Report, February 1979

Dear Mr. Kupper:

Progress on the subject contract during February is summarized in this monthly letter technical report.

Task 2.1-2.3 - The second data tape from EG&G (reference Jan. 1979 monthly report) has been processed. Contrary to expectations, only about two thirds of the data are included. Contact was made with EG&G in order to determine the status of the transcription task and when the balance of the data might be expected. After consulation with G. Kimoshita (Sandia), it was decided to hold up on final processing of the data until all (or nearly all) of the data are available. This will avoid costly duplication of computer time and effort in editing and rearranging the data. The balance of the data is expected shortly.

Task 2.4 - Underway.

Task 2.5 - Underway (awaiting above data).

Sincerely,

J. I. Craig
Associate Professor

yk

Attachments

Sandia Laboratories
PURCHASING ORGANIZATION

ALBUQUERQUE, NEW MEXICO 87115
LIVERMORE, CALIFORNIA 94550

MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 2-28-79

| | | |
|---|---|---|
| TOTAL FUNDS AUTHORIZED | | $ 99,954.00 |
| ACTUAL COST INCURRED TO DATE (2) | | 49,166.25 |
| ESTIMATED COST TO COMPLETE: (3) | | |
| 1ST MONTH FOLLOWING (1) | 4,271.00 | |
| 2ND MONTH | 4,271.00 | |
| 3RD MONTH | 4,271.00 | |
| 4TH MONTH | 4,271.00 | |
| 5TH MONTH | 4,271.00 | |
| 6TH MONTH | 4,271.00 | |
| BALANCE OF FISCAL YEAR (4) | 8,075.30 | |
| SUBSEQUENT FISCAL YEARS | 17,086.45 | |
| TOTAL ESTIMATE TO COMPLETE | | 50,787.75 |
| TOTAL ESTIMATED COST AT COMPLETION | | $ 99,954.00 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE.

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

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Monthly Technical Report: March, 1979.

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
AEROSPACE ENGINEERING

404-894-3000

DANIEL GUGGENHEIM SCHOOL
OF AERONAUTICS

June 12, 1979

E-15-609

Mr. G. T. Kupper
Sandia Contracting Representative
Sandia Laboratories
Albuquerque, NM 87115

SUBJECT: Contract 07-6958 Monthly Technical Report, April 1979

Dear Mr. Kupper:

Progress on the subject contract during April is summarized in this monthly letter technical report.

Tasks 2.1-2.3 - We have not received the tape transcriptions from EG&G and as a result have not been able to perform a final analysis on the data from September 1977 to November 1978. No contract funds have been expended for these tasks.

Task 2.4 - Underway

Task 2.5 - The attached table presents the key solar and meteorological statistics for the month of March 1979. We are continuing with the analysis of the data for the winter months (1978-1979).

Sincerely,

J. I. Craig
Associate Professor

Attachments

MONTH : 3

| DAY | COUNT | CALC. DNSF (KJ/M/M) | OBS. DNSF (KJ/M/M) | GLOBE (KJ/M/M) | AVE. PRESS (KPA) | AVE. TEMP. (D-C) | AVE. WSPD (M/S) | PCT SS |
|---|---|---|---|---|---|---|---|---|
| 60 | 95 | 15978. | 76. | 15321. | 98.89 | 12.7 | 1.2 | 37.73 |
| 61 | 96 | 14448. | 2346. | 14760. | 99.18 | 13.8 | 1.5 | 75.23 |
| 62 | 96 | 145. | 0. | 2607. | 98.73 | 15.1 | 4.0 | 0.00 |
| 63 | 96 | 3980. | 1434. | 6856. | 98.26 | 16.9 | 3.6 | 28.59 |
| 64 | 96 | 25709. | 28732. | 20356. | 98.90 | 9.0 | .9 | 96.48 |
| 65 | 96 | 26601. | 30613. | 20745. | 98.72 | 6.9 | .9 | 94.00 |
| 66 | 95 | 10056. | 6871. | 10332. | 97.98 | 7.2 | .9 | 65.38 |
| 67 | 96 | 2276. | 1244. | 7562. | 97.98 | 5.1 | .8 | 30.42 |
| 68 | 96 | 29888. | 29614. | 21710. | 98.90 | 7.6 | 1.1 | 99.65 |
| 69 | 95 | 1424. | 237. | 7239. | 98.78 | 8.6 | 1.5 | 36.72 |
| 70 | 96 | 27486. | 33053. | 22052. | 98.87 | 4.5 | 1.6 | 101.20 |
| 71 | 96 | 27971. | 33396. | 21943. | 99.23 | 8.3 | .6 | 98.75 |
| 72 | 95 | 22593. | 20365. | 19701. | 99.18 | 12.0 | 1.7 | 94.17 |
| 73 | 96 | 19588. | 21744. | 17781. | 98.87 | 13.3 | 2.2 | 70.41 |
| 74 | 96 | 29055. | 35048. | 23280. | 99.59 | 6.7 | 1.7 | 99.99 |
| 75 | 96 | 12911. | 7410. | 16606. | 100.07 | 7.0 | 1.9 | 74.23 |
| 76 | 96 | 8647. | 5008. | 13928. | 100.13 | 10.5 | 1.5 | 46.52 |
| 77 | 96 | 16850. | 12417. | 18076. | 99.49 | 14.2 | .4 | 90.66 |
| 78 | 96 | 23951. | 25648. | 21279. | 99.03 | 16.3 | .5 | 92.49 |
| 79 | 96 | 18330. | 15708. | 19168. | 98.68 | 18.3 | .7 | 90.12 |
| 80 | 96 | 7137. | 6472. | 11217. | 98.52 | 18.0 | .5 | 50.15 |
| 81 | 96 | 254. | 0. | 4363. | 98.50 | 15.9 | 2.5 | 0.00 |
| 82 | 96 | 8592. | 6780. | 12112. | 97.05 | 16.9 | 4.1 | 62.32 |
| 83 | 96 | 1940. | 1443. | 6321. | 96.98 | 7.2 | 2.5 | 22.78 |
| 84 | 96 | 21031. | 20690. | 20791. | 97.59 | 3.5 | 2.1 | 78.47 |
| 85 | 96 | 28938. | 33083. | 24457. | 98.75 | 5.5 | 1.0 | 98.83 |
| 86 | 96 | 22755. | 20819. | 20959. | 99.32 | 11.5 | .7 | 98.54 |
| 87 | 96 | 23874. | 23103. | 22401. | 99.56 | 15.2 | 1.3 | 94.16 |
| 88 | 96 | 17929. | 12505. | 19407. | 99.64 | 16.5 | 1.7 | 95.93 |
| 89 | 96 | 12076. | 6487. | 16924. | 99.48 | 17.6 | 1.7 | 85.48 |
| 90 | 96 | 2536. | 456. | 8152. | 99.28 | 16.4 | 1.0 | 26.38 |

| DAYS | AVE. CALC. DNSF | DEV. | AVE. OBS. DNSF | DEV. | AVE. GLOBE | DEV. | AVE. PRESS | DEV. | AVE. TEMP | DEV. | AVE. WIND | DEV. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 31 | 15649. | 9987. | 14284. | 12399. | 15757. | 6340. | 98.8 | .8 | 11.6 | 4.7 | 1.6 | 1.0 |

Sandia Laboratories
PURCHASING ORGANIZATION

ALBUQUERQUE, NEW MEXICO 87115
LIVERMORE, CALIFORNIA 94550

MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 4-30-79

| | | |
|---|---|---|
| TOTAL FUNDS AUTHORIZED | | $ 99,954 |
| ACTUAL COST INCURRED TO DATE (2) | | 64,504 |
| ESTIMATED COST TO COMPLETE: (3) | | |
| 1ST MONTH FOLLOWING (1) | $3,940 | |
| 2ND MONTH | 3,940 | |
| 3RD MONTH | 3,940 | |
| 4TH MONTH | 3,940 | |
| 5TH MONTH | 3,940 | |
| 6TH MONTH | -- | |
| BALANCE OF FISCAL YEAR (4) | -- | |
| SUBSEQUENT FISCAL YEARS | 15,750 | |
| TOTAL ESTIMATE TO COMPLETE | | 35,450 |
| TOTAL ESTIMATED COST AT COMPLETION | | $ 99,954 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE. (approximate)

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
AEROSPACE ENGINEERING

DANIEL GUGGENHEIM SCHOOL
OF AERONAUTICS

404-894-3000

June 12, 1979

E-15-609

Mr. G. T. Kupper
Sandia Contracting Representative
Sandia Laboratories
Albuquerque, NM 87115

SUBJECT: Contract 07-6958 Monthly Technical Report, May 1979

Dear Mr. Kupper:

Progress on the subject contract during May is summarized in this monthly letter technical report.

Tasks 2.1-2.3 - In the absence of tape transcriptions from EG&G, we are proceeding with a final analysis of the currently available data for September 1977 to November 1978 (approximately 50% of the data) along with the complete data from November 1978 onward. The attached copy of a paper presented at the 1979 ISES Congress updates the model year. Also included is a graph comparing the model (SMY) with other data and the latest met station data. The met station data for November 1978 onward through April 1979 are shown for the corresponding months; all other months are taken from earlier incomplete data (some months have as little as 7 days of valid data). As can be seen, there is good agreement for the most recent winter.

Task 2.4 - Underway

Task 2.5 - The attached table presents the key solar and meteorological statistics for the month of April 1979.

Sincerely,

J. I. Craig
Associate Professor

Attachments

RECEIVED
JUN 28 1979
OFFICE OF CONTRACT
ADMINISTRATION

# DEVELOPMENT OF A SOLAR MODEL YEAR FROM NATIONAL WEATHER SERVICE CHART DATA

J. I. Craig, Aerospace Engineering
S. M. Jeter, Mechanical Engineering
T. L. Hartman III, Mechanical Engineering
J. M. Hill, Mechanical Engineering

Georgia Institute of Technology
Atlanta, Georgia 30332

## ABSTRACT

The development of a solar model year directly from National Weather Service chart data archived at the National Climatic Center is described. A pseudo year model is constructed by selecting from all available months those 12 which most nearly match the long term monthly characteristics in a weak statistical sense. The months are selected to most nearly match the first two moments of the monthly distributions of the daily total global insolation. No attempt is made to match other meteorological characteristics. The chart data of daily global insolation for each month were digitized at 15 minute intervals and are corrected for long term instrument drift. The correction is based on a linear regression analysis of the daily total insolation measurement for the clearest of each group of 40 days over the lifetime of the particular instrument.

## 1. INTRODUCTION

One of the first tasks to be faced in designing an advanced solar energy system is that of defining and obtaining a suitable solar radiation data base for the proposed site. While some type of solar radiation measurements have been made during the past several decades at over 100 sites across the U.S., much of the raw data is of questionable quality and beset with frequent gaps. Observations of high quality and accuracy have been made only at a very few sites. The accuracy of this data has been markedly improved by the recently completed rehabilitation of 26 primary stations and the synthesis from this of hourly data for 222 other sites. The data will be further improved as measurements from the 28 National Weather Service (NWS) solar observation stations and 8 regional solar meteorological research and training sites become available.

The present model year was developed to support design studies for the planned Solar Total Energy Large Scale Experiment at Shenandoah, Georgia, which will provide medium temperature steam for electric power generation, absorption cooling and process heat for a knit-wear plant. At the study outset, the only available data consisted of daily totals of global insolation recorded by the NWS at the Atlanta Airport station 35 miles to the northeast and similar daily totals recorded by the cooperative station at Griffin, Georgia, 40 miles to the south

A number of methods have been proposed to construct solar data bases from other meteorological data when no primary measurements of solar radiation exist (1,2). The procedures are based on correlations established between cloud cover and other variables and actual measured solar radiation at a limited number of sites. These will not be discussed, and due to the uncertain correlation with data from other sites were not considered for use in constructing the present SMY. Rather, the present effort was directed towards development of procedures for employing the extensive daily total global insolation data collected by the NWS and archived at the National Climatic Center (NCC). The data are available in a few cases as hourly observations but generally as daily totals that were originally obtained from mechanical integrators incorporated into the chart recorders used to log the pyranometer outputs. The integrator totals were the primary observations, however, the original charts from NWS stations were archived as well since they contained operational notes, integrator start and end of day readings, and generally provided indications of the instrument system status. Only the daily totals are available from cooperative stations.

The emphasis in the present work is directed to two points: (i) development of a decision procedure for selecting the most suitable data from among all available data, and (ii) design of an efficient procedure for extracting hourly data in a computer-readable format from the daily charts.

## 2. AVAILABLE SOLAR DATA

At the outset of the study, contact with the NCC determined that daily totals of the global insolation at the Atlanta Airport NWS station over approximately 20 years had been archived. No chart data had been archived for the cooperative Griffin station and thus it was dropped from further consideration.

A visit was made to the NCC to determine the quality and extent of the charts for Atlanta. Immediately, it was found that much useful station operation data (instrument changes, recalibrations, malfunctions) were available on the charts. A simple procedure was developed to examine each chart by hand in monthly groups and to record the significant notations or missing charts on a small portable cassette tape recorder. The entire set of charts covering over 20 years were examined in this manner in approximately 1 man-day. Subsequently, the cassettes were transcribed into a logbook for reference purposes.

The daily total radiation data from the chart integrator are available in the TD480 series of computer-compatible magnetic tapes. These data as qualified by the logbook were used as the basis for the SMY selection procedure.

## 3. MODEL YEAR SELECTION PROCEDURE

Two essential features must be included in any SMY developed: (i) the magnitude characteristics should agree closely with those for the long-term historical data, and (ii) the temporal features should also be similar to those in the historical data. The first is equivalent to requiring close matching of the sample distribution functions and can be determined, for example, by using a chi-square goodness-of-fit test (3), or somewhat more directly, by matching a finite number of moments of the sample distribution. The second requirement involves matching the sequential characteristics in the data, e.g. runs of sunny, cloudy, cool, warm, etc. days, and can be determined by nonparametric run tests (3) or by matching autocorrelation functions. In the case of a general meteorological model year there are a variety of parameters that must be matched in a statistical sense to the long term characteristics (e.g., insolation, temperature, wind characteristics, precipitation) and the selection procedures can become quite involved. However, if concern is primarily with the solar radiation characteristics, this selection procedure can be simplified by basing it on these features alone. The problem thus reduces to suitably matching the solar radiation characteristics, in the present case, the daily total global insolation, so that these features in the model year are statistically similar to what will be observed at the site over extended periods of time.

It has been tacitly assumed that this matching procedure will be applied to data sequences of one year. This is a somewhat arbitrary assumption since there obviously are year-to-year variations in the data as well. However, the concept of using a single year model is based on the practical matter of economics and the realization that from a solar energy utilization point of view, the most pronounced variations in the data occur over yearly periods of time. In constructing a single year model, however, the immediate problem is to maintain on a seasonal basis (e.g., winter, spring, summer, fall) a suitable match with the long-term characteristics. It is, for example, quite possible to have an usually cloudy summer followed by an average or a clearer than average winter. One approach to this problem is simply to discard in succession the most extreme years until the "least extreme" year remains (4). Another method is to construct a pseudo year by selecting the most suitable seasons or even months from among all available. This type of model obviously will lose some internal consistency ( most obvious in the autocorrelation function).

The present approach is to construct a pseudo year on a monthly basis by selecting for each month the most suitable from among all of the same months for which data are available. Monthly transitions occur at midnight when the insolation is zero but other data can be smoothed over the adjacent 2 to 3 hours. This approach has been taken for the following reasons.

(1) The seasonal insolation characteristics generally are of critical importance in simulating the annual performance of solar systems.

(2) The available data base is not complete so it would be very difficult to select an actual year without missing data.

(3) Monthly segments are long enough to preserve sequential structure but short enough to account for seasonal variations.

The actual selection procedure for picking the 12 typical months from among the 20 years of available data was based on making a weak statistical match with the long term characteristics. That is, the individual months are selected in each case by closely matching the mean daily total global insolation and its variance over that month with the average monthly means and variances taken over all the months for which data are available. The monthly data are weighted in proportion to the amount of data available (i.e., months with missing data are given less weight). For the model and long term data to be strictly equivalent in the statistical sense, one would have to match not only the means but also all of the higher moments of the various distributions. From a practical point of view the latter approach is not easily carried out and one must resort to the weaker match.

A table of monthly means and variances, the long-term averages for each month, and the yearly averages for each year was prepared. Consideration was given to developing an algorithm to select the months automatically, but in reality the selection could be clearly made by hand with reference to the additional data qualifications in the logbook. The months shown in Table 1 were selected.

Several general observations concerning this approach should be made. A more sensitive comparison could have been made, especially if more than a single parameter were under consideration, by using one of several goodness-of-fit tests. The most common of these is the chi-square (3) although several others have been considered (5). The similar FS statistic was used in a contemporary study to select typical meteorological years (TMY) for the 26 SOLMET rehabilitation sites (6). In that study, temperature and wind were also matched but with much less weight than the solar. While this type of approach is generally more satisfactory, the second order moment matching procedure used in the present study was selected because of its simplicity when dealing with a data base which includes significant amounts of missing data. For example, only months with better than 97% complete data were considered as candidates which restricted some choices to one of less than 10 months. The present method is also less sensitive to distribution shapes, but again this is not a major problem since the selection procedure in each case deals with groups of similar months rather than all months. Finally, for comparison purposes, a chi-square type goodness-of-fit test was applied to the same data but with no regard for incomplete months. In all but one case the selected months were within the group of 2-5 months with the smallest sample statistic. In these tests, the reference distribution was taken as the sample distribution for all years of a given month.

## 4. CHART DIGITIZATION

The unique aspect of the present SMY is its direct digitization of graphical data contained on each of the daily circular recorder charts for the selected model year months. This step was anticipated to be the most time consuming since hourly or more frequent digitization intervals were initially planned. Several aspects of the chart data, a sample of which is shown in Fig. 1, appear to present major problems. First, and most obvious is the nonlinear scale system employed on the charts. While the radial scale is almost linear, the time or angular scale is shifted as a function of radial position in order to accommodate the particular recorder pen movement. This would appear to complicate any attempt to use an automated digitization procedure, based for example on use of a cartesian coordinate digitizer. Secondly, the nature of the data on partly cloudy days is such that it is impossible to accurately represent the short period (5 min. or less) fluctuations in any practical manner. Finally, on some of the charts, there have been various adjustments, especially in the time position, that must be properly accounted for.

After considerable study and discussions with NCC personnel, a novel and efficient method was developed that would allow digitization of the charts at 15 min. intervals. Since the charts are ruled in 15 min. increments, it is relatively simple to read off the radial coordinate where the trace crosses each of the time lines. In those cases where considerable fluctuations in the radiation occur, this process must be carried out largely by visual estimation over the preceeding time interval. (It is encouraging that in many other similar instances, local visual estimation or averaging of chart data has yielded results that are in good agreement with more precise and time consuming methods.) This procedure yields a sequential record of radiation at 15 min. intervals relative to the starting hour. The procedure was significantly automated by use of NCC's HP9830 calculator and flat-bed cartesian digitizer which allowed the actual coordinates to be read and stored on cassette tapes. Since the data are taken sequentially, one only needs to know the starting hour; the insolation can be computed from the radial distance of the point from the origin which is defined to be at the chart center.

A visit was made to the NCC and in 3 man-days the selected charts were digitized and stored on cassette tapes. Xerox copies of all digitized charts were also obtained for reference. Afterward, another HP9830 calculator with suitable peripherals was used to copy the cassettes to Georgia Tech's CDC central computer mainframe.

Next, an extensive period of data verification was carried out. Using the digitized data, a copy of each chart was constructed on a graphics terminal and the result compared to the Xerox chart copy. Any shifts or discrepancies were removed by editing. Then, each chart record was scaled and numerically integrated and the resultant daily total was compared to the tabulated NCC value (from the ball-and-disc integrator in the site recorder). If a discrepancy of 2% or more was found, the chart data was reexamined and adjusted if possible. (A bad integrator reading was found in one case.) Finally, the data were corrected for any problems noted on the charts.

## 5. INSTRUMENT REHABILITATION

It has been widely recognized that insolation data from the old NWS network of stations is subject to significant errors for a variety of reasons. The rehabilitation is based on a regression analysis of the performance of each instrument under clear sky conditions over its lifetime. It is similar to a method proposed earlier (7) and provides a realistic means for correcting for an observed trend in insolation data as time passes. The available information is taken as the daily total global insolation data on the TD480 tape along with the station instrument logs obtained from NOAA. Because the data for a given instrument is in some cases limited, an attempt has been made to exclude systematic, periodic or random effects as follows:

(1) To exclude weather effects to the maximum extent possible, only the data for the clearest day out of 40 day intervals are used. This is defined for the present data as the day with the greatest percent of possible insolation (presumably only a clear day).

(2) To exclude seasonal effects, only full years are considered.

The actual procedure can be outlined as follows. First, the data covering the desired period of operation (1952-1974) are examined and the clearest day total global insolation for each 40 day interval is selected. Next, the annual means of the "clear day" data are compiled and a linear regression analysis is carried out to determine the long term degradation over each year of operation for each instrument. The degradation can thus be expresses as

$$y = b_0 + b_1 x$$

where

- $y$ = annual mean percent of possible daily total global insolation
- $x$ = time since instrument installation
- $b_0$, $b_1$ = linear regression coefficients

Using this, the pyranometer response is deduced to degrade in a linear manner as:

$$C = C_0 \, (1 + (b_1/b_0)/x)$$

where $C$ = current response, and $C_0$ = calibrated response. Since $b_0$ is an extrapolation to a presumed condition, it was felt that a better normalization factor above would be the average annual means, $\langle y \rangle$.

This yields:

$$C = C_0 \, (1 + (b_1/\langle y \rangle)x) = C_0/f$$

where f is the fractional annual degradation. While these parameters are derived based on daily totals of insolation, it is reasonable to assume that they apply as well to the instantaneous instrument response. Thus, if given an observed pyranometer output, $I_o$, the actual reading, $I_a$, can be deduced as:

$$I_a = I_o \, f$$

where the argument x in the definition of f is the number of years the instrument has been in operation measured to the mid-point of the month in question.

In addition to the degradation, account must also be taken of other factors as follows:

(1) Temperature compensation

(2) Cross-match calibration errors

(3) Calibration scale changes

These problems are discussed in general terms in the SOLMET final report (2). Table 1 shows the final result of applying all of the above corrections to the SMY data. The results are also shown in Fig. 2 for the complete station history. Here, both the corrected and uncorrected clearest day data expressed as a percent of the extraterrestrial value are plotted versus time. Each instrument change is noted as well.

## 6. FINAL MODEL YEAR ASSEMBLY AND COMPARISON

The radiation data must finally be supplemented with related meteorological measurements and combined to form the complete SMY. This has been done for the present SMY and the results converted into a 15 min. SOLMET format consisting of the standard 163 character records but in the present case scaled for 15 min. rather than the standard hourly intervals. The meteorological data were obtained from the NCC TDF-14 series of surface observations for the Atlanta Airport Station. In addition, since the chart insolation data are in solar time, the corresponding local standard times were computed. The decomposition of global insolation into beam and diffuse components was carried out by Dr. Charles Randall of the Aerospace Corporation (8).

## 7. ACKNOWLEDGEMENT

The work reported on was supported in part by Sandia Labs (NM) under Contract 07-6958. Their support is gratefully acknowledged.

## 8. REFERENCES

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Radiation on Cloudy Days," ASHRAE Transactions, Part I, pp. 227-233.

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(8) Randall, C. M. and Whitson, M. E., "Hourly Insolation and Meteorological Data Bases Including Imporved Direct Insolation Estimates" Sandia Labs Rept. No. SAND78-7047, 1977.

TABLE 1. Comparison of Months Selected

| Year | Long-Term Mean | Long-Term Std Dev | SMY Mean | SMY Std Dev |
|---|---|---|---|---|
| Jan 1953 | 205 | 110 | 200 | 106 |
| Feb 1971 | 275 | 145 | 285 | 146 |
| Mar 1969 | 375 | 176 | 378 | 159 |
| Apr 1965 | 470 | 182 | 446 | 157 |
| May 1957 | 528 | 173 | 520 | 173 |
| Jun 1957 | 538 | 154 | 521 | 153 |
| Jul 1970 | 512 | 135 | 525 | 130 |
| Aug 1959 | 478 | 125 | 505 | 97 |
| Sep 1963 | 397 | 140 | 389 | 132 |
| Oct 1967 | 337 | 127 | 333 | 124 |
| Nov 1967 | 250 | 108 | 247 | 118 |
| Dec 1970 | 194 | 100 | 193 | 101 |

Note: all values in Langleys/day

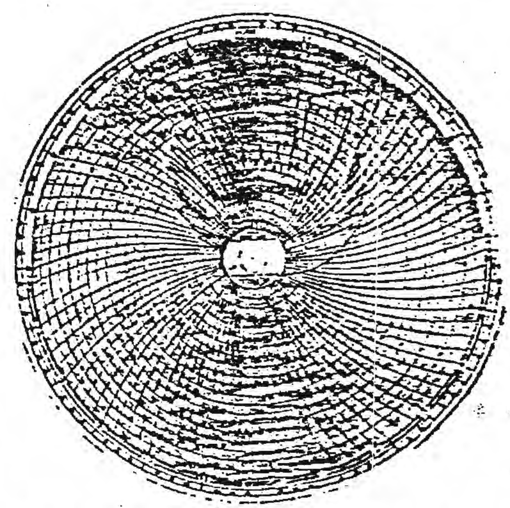
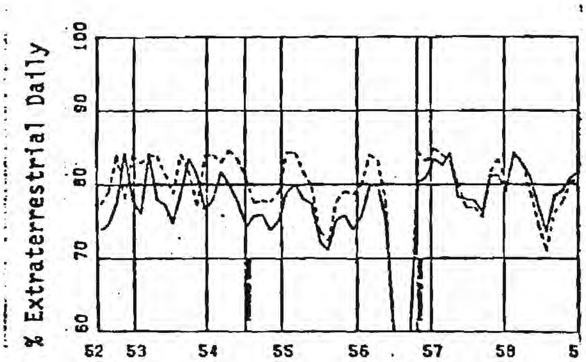


Fig. 1. Typical NCC Circular Chart



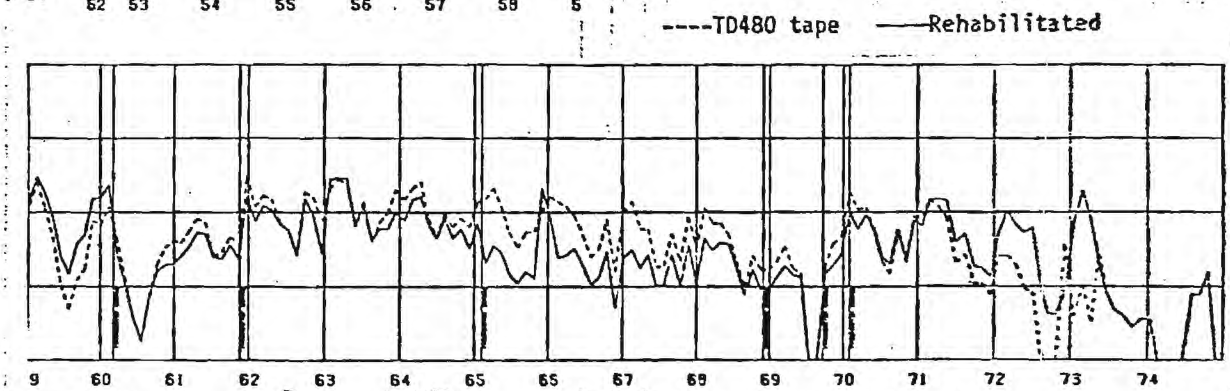
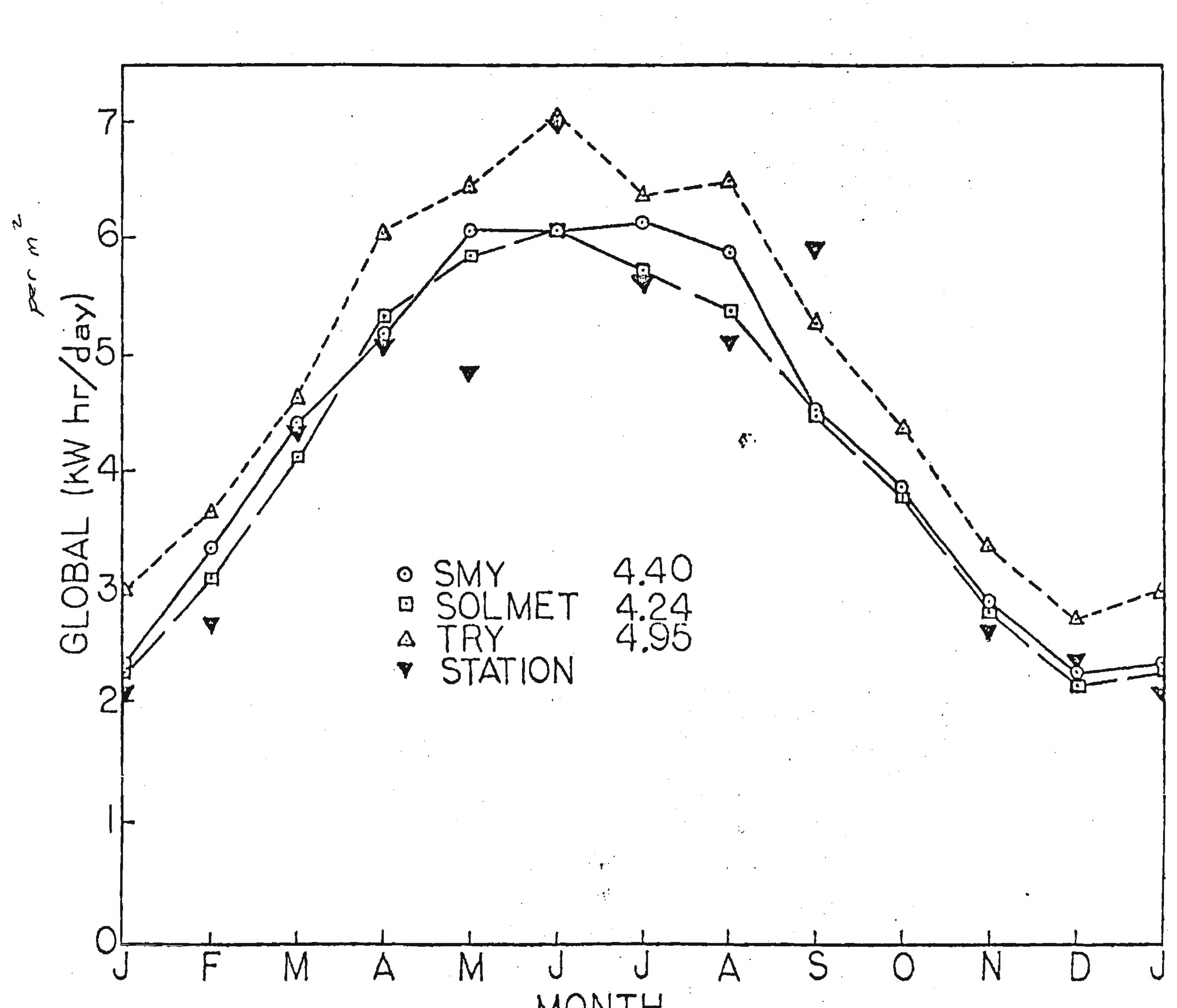




Fig. 2. Global Insolation for Clearest Day of Each 40-day Period (1952-1975)



per m^2
GLOBAL (kW hr/day)
SMY 4.40
SOLMET 4.24
TRY 4.95
STATION
J F M A M J J A S O N D J
MONTH
0 1 2 3 4 5 6 7

MONTH : 4

| DAY | COUNT | CALC. DNSF (KJ/M/M) | OBS. DNSF (KJ/M/M) | GLOBE (KJ/M/M) | AVE. PRESS (KPA) | AVE. TEMP. (D-C) | AVE. WSPD (M/S) | PCT SS |
|---|---|---|---|---|---|---|---|---|
| 91 | 95 | 16905. | 12744. | 19690. | 98.77 | 18.7 | 2.0 | 95.11 |
| 92 | 96 | 349. | 14. | 5724. | 98.53 | 18.7 | 2.1 | 4.04 |
| 93 | 96 | 1063. | 231. | 5474. | 98.49 | 14.4 | .9 | 8.05 |
| 94 | 96 | 8701. | 7522. | 11716. | 98.21 | 16.9 | 1.6 | 48.16 |
| 95 | 95 | 30641. | 24346. | 26416. | 98.82 | 11.1 | .9 | 98.04 |
| 96 | 96 | 29326. | 28105. | 25678. | 99.36 | 12.6 | 1.1 | 97.77 |
| 97 | 96 | 25368. | 28987. | 24216. | 99.37 | 14.1 | .5 | 97.50 |
| 98 | 96 | 922. | 183. | 5031. | 98.52 | 13.4 | 1.3 | 9.92 |
| 99 | 95 | 25149. | 24556. | 23721. | 97.60 | 14.5 | 2.8 | 96.97 |
| 100 | 96 | 25963. | 25828. | 25231. | 98.49 | 11.2 | .9 | 90.78 |
| 101 | 96 | 3177. | 1466. | 10500. | 99.66 | 17.3 | 3.1 | 37.40 |
| 102 | 96 | 2302. | 551. | 7375. | 98.62 | 17.8 | 2.6 | 15.70 |
| 103 | 96 | 292. | 14. | 1301. | 98.21 | 15.7 | 1.6 | 1.96 |
| 104 | 96 | 30351. | 15150. | 27684. | 98.53 | 14.3 | 1.0 | 95.67 |
| 105 | 96 | 30080. | 7535. | 26964. | 98.62 | 14.9 | 1.1 | 95.42 |
| 106 | 96 | 29999. | 13. | 27096. | 98.93 | 14.7 | 1.2 | 0.00 |
| 107 | 96 | 28133. | 0. | 26430. | 99.12 | 16.1 | 1.0 | 0.00 |
| 108 | 96 | 18481. | 948. | 21390. | 99.18 | 15.8 | .8 | 21.26 |
| 109 | 96 | 17826. | 15836. | 22264. | 99.14 | 15.3 | .9 | 96.37 |
| 110 | 96 | 24423. | 23097. | 24690. | 99.05 | 16.8 | .7 | 96.13 |
| 111 | 95 | 23791. | 20604. | 25127. | 99.13 | 17.8 | 1.0 | 99.13 |
| 112 | 96 | 2531. | 416. | 10712. | 99.25 | 17.3 | .8 | 32.52 |
| 113 | 96 | 7514. | 3527. | 16127. | 99.17 | 19.5 | 2.6 | 64.88 |
| 114 | 96 | 3729. | 1035. | 13171. | 98.08 | 18.7 | 2.5 | 43.78 |
| 115 | 95 | 163. | 9. | 3043. | 97.91 | 16.0 | 2.6 | 1.90 |
| 116 | 96 | 7283. | 4138. | 13358. | 97.24 | 18.1 | 1.5 | 41.68 |
| 117 | 96 | 23906. | 23200. | 25750. | 97.84 | 14.8 | 1.1 | 75.60 |
| 118 | 96 | 28233. | 28906. | 27704. | 98.41 | 12.1 | 1.0 | 96.17 |
| 119 | 96 | 17402. | 14060. | 22243. | 98.76 | 10.5 | .4 | 82.78 |
| 120 | 96 | 24738. | 23930. | 25421. | 98.83 | 14.2 | .5 | 90.10 |

| DAYS | AVE. CALC. DNSF | DEV. | AVE. OBS. DNSF | DEV. | AVE. GLOBE | DEV. | AVE. PRESS | DEV. | AVE. TEMP | DEV. | AVE. WIND | DEV. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | 16293. | 11625. | 11233. | 11141. | 18352. | 8746. | 98.7 | .5 | 15.4 | 2.4 | 1.4 | .8 |

Sandia Laboratories
PURCHASING ORGANIZATION

ALBUQUERQUE, NEW MEXICO 87115
LIVERMORE, CALIFORNIA 94550

# MONTHLY COST STATUS REPORT

CONTRACT NO. 07-6958

PERIOD ENDING (1) 5-31-79

| | | |
|---|---|---|
| TOTAL FUNDS AUTHORIZED | | $99,954 |
| ACTUAL COST INCURRED TO DATE(2) | | 67,112 |
| ESTIMATED COST TO COMPLETE:(3) | | |
| 1ST MONTH FOLLOWING (1) | $4,105 | |
| 2ND MONTH | 4,105 | |
| 3RD MONTH | 4,105 | |
| 4TH MONTH | 4,105 | |
| 5TH MONTH | -- | |
| 6TH MONTH | -- | |
| BALANCE OF FISCAL YEAR(4) | -- | |
| SUBSEQUENT FISCAL YEARS | 16,422 | |
| TOTAL ESTIMATE TO COMPLETE | | 32,842 |
| TOTAL ESTIMATED COST AT COMPLETION | | $99,954 |

NOTES:

(1) LAST FULL MONTH FOR WHICH ACTUAL COSTS ARE AVAILABLE.

(2) COST INCLUDES APPLICABLE FEE. (estimated)

(3) ESTIMATES FOR COSTS TO BE INCURRED (DO NOT INCLUDE COMMITMENTS), INCLUDING APPLICABLE FEE.

(4) FISCAL YEAR IS 10/1 THRU 9/30. BALANCE OF FISCAL YEAR MEANS ALL MONTHS IN A FISCAL YEAR FOLLOWING THE 6TH MONTH SHOWN ON THE LINE ABOVE.